Paroscientific, Inc.
Digiquartz® Pressure Instrumentation

Digiquartz Broadband Intelligent Instruments with RS-232 and RS-485 Interfaces

Series 1000 / 6000 / 9000
Intelligent Pressure Transmitter

Series 8000 Intelligent Depth Sensor

Model 715 Display

RS-232 / RS-485 Serial Interface Board

User Manual

"The standard by which other standards are measured"

Digiquartz®
Technology

Digiquartz® Broadband Intelligent Instruments with RS-232 and RS-485 Interfaces

User Manual

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1 Introduction

Thank you for your recent Digiquartz® Intelligent Transmitter or Depth Sensor purchase. This manual describes operation of the entire line of Paroscientific Digiquartz Intelligent Transmitters and Depth Sensors equipped with single RS-232 or dual RS-232/RS-485 ports.

NOTE: To determine if your Digiquartz Intelligent device supports dual RS-232/RS-485 or RS-232 only serial interface, please refer to product documentation.

1.1 Latest Features

Nano-Resolution - Starting with firmware revision R5.10 or later, it is now possible to achieve parts-per-billion resolution (nano-resolution) as opposed to parts-per-million resolution in standard mode. This feature is easily enabled/disabled via software commands. Please refer to Section 6, page 63 for additional information on using nano-resolution.

Precise Measurement Time Interval Command - Allows the user to collect measurements at precise data rates. Please refer to Section 5.5, page 38 for additional information on using the precise measurement time interval command.

Compound Measurement Commands - Allows the user to simultaneously acquire multiple measurement values such as signal periods and compensated pressures in a more efficient and convenient manner than taking the measurements separately. Please refer to Section 5.3.3, page 32 for additional information on using compound measurement commands.

1.2 Conventions Used In This Manual

The following conventions are used throughout this manual:

Digiquartz Intelligent Device - Any Series 1000, 6000, or 9000 Intelligent Transmitter, or Series 8000 Intelligent Depth Sensor.

Digiquartz Intelligent Transmitter - Any model from the Series 1000, 6000, or 9000 product lines.

Digiquartz Intelligent Depth Sensor - Any model from the Series 8000 product line with RS-232 and/or RS-485 capabilities.

CAUTION

is used to draw your attention to a situation that may result in an undesirable outcome, but will not damage an Intelligent device.

WARNING

is used to draw your attention to a situation that may result in permanent damage to an Intelligent device.

DANGER

is used to draw your attention to a situation that may result in injury.

1.3 Warnings and Safety Precautions

Digiquartz Pressure Transmitters and Depth Sensors are precision devices, and as such, they should be operated with a certain degree of care to ensure optimum performance.

WARNING

It is recommended that the input pressure typically not exceed 1.2 times the rated full-scale pressure. Calibration can be affected if this limit is exceeded, and permanent damage can result if the unit is sufficiently over-pressured. Certain custom products may have lower requirements; please refer to the product SCD for actual safe pressure rating.

WARNING

Excessive mechanical shock may cause irreparable damage. Do not drop an Intelligent device, or allow tools to fall on the unit or its pressure port.

1.4 Hardware Descriptions

1.4.1 Intelligent Transmitters (Series 1000 / 6000 / 9000)

Digiquartz Intelligent Transmitters consist of a pressure transducer and a serial interface board in an integral package. Commands are sent and measurement data is received via one RS-232 and one RS-485 serial port. Measurement data is provided directly in user-selectable engineering units with a typical total accuracy of 0.01% or better over a wide temperature range. Pressure measurements are fully temperature compensated using a precision quartz crystal temperature sensor. Each intelligent transmitter is preprogrammed with calibration coefficients for full plug-in interchangeability.

1.4.2 Intelligent Depth Sensors (Series 8000)

Digiquartz Intelligent Depth Sensors consist of a pressure transducer and a serial interface board in a rugged waterproof package. Commands are sent and measurement data are received via one RS-232 and one RS-485 serial port. Measurement data are provided directly in user-selectable engineering units with a typical total accuracy of 0.01% or better

over a wide temperature range. Pressure measurements are fully temperature compensated using a precision quartz crystal temperature sensor. Each intelligent depth sensor is preprogrammed with calibration coefficients for full plug-in interchangeability.

1.4.3 Model 715 Display

The Model 715 is an LCD display unit that can be used with Digiquartz Intelligent devices via serial interface. It features a two-line, 16 character alphanumeric LCD display that is backlit to ensure readability even in low light conditions. The Model 715 can communicate with a Digiquartz Intelligent device via either RS-232 or RS-485.

The Model 715 is housed in a sturdy metal enclosure that conforms to DIN specifications, and is designed for easy panel mounting.

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2 Features and Functions

The following features and capabilities are common to all Digiquartz Intelligent Transmitters and Depth Sensors except as noted. For the added benefits of nano-resolution signal processing, please refer to Section 6, page 63.

2.1 Measurement Basics

The outputs from Digiquartz pressure transducers are two square wave signals whose period is proportional to applied pressure and internal transducer temperature. The Intelligent electronics measures these signals using a technique similar to that of a common laboratory frequency counter. Like the frequency counter, a signal must be integrated, or sampled, for a specified period of time to measure its period. The time over which the signal is sampled determines the resolution of the measurement. Longer sampling times increase resolution, but result in a slower sampling rate.

Digiquartz Intelligent devices allow you to set the integration time between 0.001 and 270 seconds in 0.001 second increments. Pressure and temperature integration times can be set independently. Measurements can be continuously taken in the background, or can be initiated when a measurement command is received. These features can be used to configure the intelligent device according to the data acquisition and resolution requirements of your application. Refer to Section 7.1, page 69 for more information about integration time, resolution, and sampling rate.

2.2 Measurement Descriptions

One or both of the transducer's pressure and temperature signals are sampled, or integrated, depending on the type of measurement requested.

PRESSURE MEASUREMENTS

Pressure measurements are by far the most common. Pressure measurements are fully temperature-compensated, and therefore require an internal temperature measurement.

When a pressure measurement is made, the following sequence occurs:

1. The temperature and pressure signal periods are measured simultaneously.
2. A temperature-compensated pressure value is calculated using the pressure period, temperature period, and the calibration coefficients.
3. The pressure value is output.

INTERNAL SENSOR TEMPERATURE MEASUREMENTS

Internal sensor temperature is normally only used for temperature compensation of pressure, but can be requested independently for diagnostic purposes.

When an internal sensor temperature measurement is made, the following sequence occurs:

1. The temperature signal period is measured.
2. The temperature value is calculated using the temperature period and the calibration coefficients.
3. The temperature value is output.

PRESSURE AND TEMPERATURE PERIOD MEASUREMENTS

Period measurements are used mainly for calibration and diagnostic purposes, but may be useful in high-speed sampling applications.

When a period measurement is made, the following sequence occurs:

1. The pressure or temperature signal period is measured.
2. The period value is output.

Refer to Section 5.3, page 28 for detailed measurement command descriptions.

NANO-RESOLUTION

Starting with firmware revision R5.10 or later, it is now possible to achieve parts-per-billion resolution (nano-resolution) as opposed to parts-per-million resolution in standard mode. This feature can be easily enabled/disabled via serial commands. Please refer to Section 6, page 63 for additional information on this new feature.

2.3 Measurement Modes

INTEGRATION MODE VS. FETCH MODE

When in Integration Mode, measurements are initiated when a measurement command is received. Data is output when the new measurement is complete. This is the mode in which Digiquartz Intelligent devices have traditionally operated. In Fetch Mode, measurements are continuously taken in the background. When a measurement command is received, the most recently acquired measurement value is immediately output. Refer to FM command on page 44 for more information.

SEQUENTIAL INTEGRATION VS. SIMULTANEOUS INTEGRATION

Until recently, Digiquartz Intelligent devices used a Sequential Integration scheme for measuring the sensor's pressure and temperature signals. With Sequential Integration, the temperature period is integrated first, followed by the pressure period.

Recent advances in microprocessor technology have enabled Digiquartz transmitters and depth sensors to integrate the temperature and pressure signals simultaneously. Simultaneous Integration results in faster data acquisition without sacrificing measurement resolution. Simultaneous Integration is available in all Digiquartz transmitters and depth sensors with firmware version R4.00 and later. For backward compatibility with earlier units, a Sequential Integration Simulation mode is also available. The Sequential Integration Simulation uses Simultaneous Integration but produces measurement timing similar to units with firmware versions prior to R4.00.

The following figure illustrates the differences between Sequential Integration, Simultaneous Integration, and Sequential Integration Simulation. Refer to Section 5.7, page 43 for more information about Sequential and Simultaneous Integration.

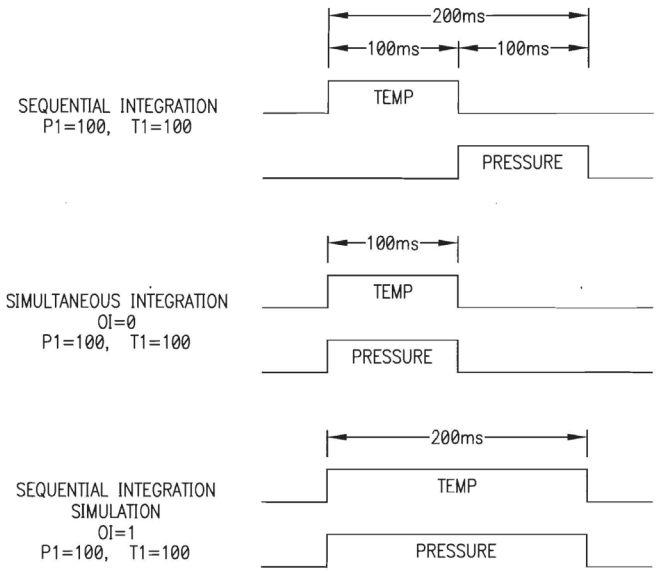

FIGURE 2-1: Timing Diagram - Simultaneous vs.Sequental Integration

2.4 Sampling Types

Options available for measurement sampling are listed below. Refer to Section 5.3, page 28 for detailed measurement command descriptions.

Single Measurement Sampling - These commands will output a single measurement value each time the command is received.

Continuous Measurement Sampling - These commands will repeatedly output measurement data until commanded to stop.

Sample and Hold Measurement Sampling - These commands are similar to single measurement sampling, but the measurement value is not output until a separate command is sent. This type of sampling is useful when you need to simultaneously trigger measurements from multiple units, and then read them one by one in a particular order.

2.5 Engineering Units

Pressure values can be expressed in the following engineering units. Refer to the **UN** command in Section 5.10, page 46 for details.

- psi
- hPa (mbar)
- bar
- kPa
- MPa
- in Hg
- mm Hg (torr)
- m H20
- user-defined units

Internal temperature values can be expressed in units of Celsius or Fahrenheit (°C or °F). Refer to the **TU** command on page 48 for details.

2.6 Serial Data Output Modes

In addition to the sampling types described in Section 2.4, Digiquartz Intelligent devices can also be configured to provide continuous pressure measurement data whenever power is applied. Refer to Section 5.9, page 45 for details.

2.7 Power Management

You can configure a Digiquartz Intelligent device to automatically switch to a low power "sleep" state after a user-defined period of serial inactivity, thus conserving power. When serial activity resumes, the unit will "awaken", allowing normal operation. Sleep mode is not available with continuous pressure output or nano-resolution. Refer to Section 5.11, page 48 for details.

2.8 Tare and Overpressure

You can configure the Digiquartz Intelligent device to subtract a value from each subsequent pressure measurement. This process is referred to as 'taring.' You can tare to the current pressure value, or to any value you specify. Taring can be initiated by contact closure via a dedicated digital input line, or by serial command. A dedicated digital output and/or a special character in the measurement data can be used to indicate whether taring is in effect. Refer to Section 5.12, page 49 and Section 10, page 83 for details.

You can configure the Digiquartz Intelligent device to indicate whether the measured pressure exceeds a user-specified setpoint. This indication is provided via a dedicated digital output line. Refer to sections cited in previous paragraph for details.

NOTE: Tare and overpressure I/O lines are not available for RS-232 only instruments or Digiquartz Intelligent Depth Sensors.

2.9 Measurement Data Formatting

Several serial data formatting options have been provided, and are listed below. Refer to Section 5.13, page 52 for details.

User-Defined Commands - Lets you create your own custom measurement commands, containing any combination of measurement values and text strings. See the **OF** and **OM** commands for details.

Engineering Unit Suffix - Appends the engineering unit to pressure and temperature measurement data. See the **US** command for details.

Underscore Separator - Adds underscore(s) to pressure and temperature measurement data to separate the measurement value from the address header and optional engineering unit. See the **SU** command for details.

Tare Indicator - Adds an uppercase 'T' character to pressure measurement data to indicate a tared value. See the **ZI** command for details.

Data Logger Format - Converts measurement data to a predictable fixed-length and fixed-position format to simplify parsing by data loggers and other programmable serial hosts. See the **DL** command for details.

User-Defined Unit Label - Lets you define the 4-character unit label to be used when the user-defined pressure unit is selected. See the **UM** command for details.

2.10 RS-232 and RS-485 Serial Communications

Commands for Digiquartz Intelligent devices are sent via serial communications. Response data, if any, will be output from the port that received the command. Common baud rates between 300 and 115,200 baud are supported. The serial protocol is fixed at 8 data bits, no parity, and 1 stop bit.

Up to 98 units and an RS-232 serial host can be interconnected to form a serial loop network. Refer to Sections 5.2, 8.4, and 11 for details. Additionally, up to 98 units and an RS-485 serial host can be interconnected to form a 2-wire or 4-wire RS-485 multi-drop network. Refer to Sections 5.2, 8.3, and 11 for details.

Communication with a specific Digiquartz Intelligent device occurs by sending commands to its ID number. You can also send certain commands to all devices on a network by sending the command to the global address. Refer to Sections 4.3, 4.4, and 5.18 for details.

2.11 Differences Between RS-232 and RS-485 Ports

Generally, Digiquartz Intelligent devices respond identically to commands received on either port, with the following exceptions:

- Global commands received by the RS-232 port are re-transmitted. This enables a global command to be relayed to each device in an RS-232 serial loop network. Refer to Section 8.4, page 76 for more information about RS-232 serial loop networking.
- Commands received by the RS-232 port that are addressed for other devices are re-transmitted. This behavior is necessary to support RS-232 serial loop networking. Refer to Section 8.4, page 76 for more information about RS-232 serial loop networking.
- Global commands received by the RS-485 port never generate a response. This prevents a data collision from occurring if all devices on a multi-drop network were to respond simultaneously. Refer to Section 8.3, page 74 for details.

2.12 Calibration

Digiquartz Intelligent devices are shipped fully calibrated. Calibration data is shipped with the unit in printed form, and is also stored within the device in non-volatile memory. These values should not be modified unless it is absolutely necessary to do so, and then only with extreme caution. See Section 5.17, page 60 and Section 13, page 99 for details.

2.13 Unit Identification

Digiquartz Intelligent devices are shipped with several unit identification values stored in non-volatile memory. These read-only values include:

- Serial and model numbers
- Full-scale pressure
- Transducer type.

Refer to Section 5.14, page 55 for details.

2.14 Model 715 Display

Digiquartz Intelligent devices can be used with the Model 715 Display to display pressure, temperature, and user-defined alphanumeric information. The Model 715 can communicate with Digiquartz Intelligent devices via either RS-232 or RS-485. User-defined alphanumeric display information can be stored in the Digiquartz Intelligent device, or can be sent directly from serial host to Model 715 display. Intelligent devices support several commands that control the Model 715 display. Refer to Section 5.15, page 56 for details.

Digiquartz Intelligent Devices with RX.XX series firmware are only compatible with the Model 715 Display, and not with the older Model 710 Display. Older Digiquartz Intelligent Devices with SX.XX series firmware are only compatible with the older Model 710 Display, and not with the Model 715 Display.

3 Installation and Quick Start

3.1 Installation

Digiquartz Intelligent Transmitters can generally be mounted in any orientation. Mounting hole patterns for units so equipped can be found on the Specification Control Drawing (SCD) supplied with the unit.

CAUTION

Pressure head effects vary with transmitter orientation, and result in zero offsets. These effects are more pronounced when liquid-filled pressure lines are being used. These effects can be minimized by keeping the transmitter pressure port and the pressure source at the same elevation, or by making an offset correction to compensate for the pressure head.

3.1.1 Pressure Ports and Buffer Tubes

Digiquartz Intelligent Transmitters typically include a nylon or stainless steel buffer tube. The buffer tube is an integral part of the mechanical shock protection system of the device.

Parker A-Lok or equivalent nut and ferrule compression tube fittings are used on most Digiquartz Intelligent Transmitters. The Series 1000 devices use 1/8” diameter tube fittings for installation. Two 7/16" wrenches are required when making or breaking any 1/8-inch pressure fitting. The first wrench is used to stabilize the stationary fitting, and the second wrench is used to turn the other fitting.

The Series 9000 transmitters use a 1/4” Modified HIP or equivalent fitting. A 5/8” wrench and 3/4” wrench are required to make and break these connections.

CAUTION

It is recommended that new pressure fittings are installed finger tight, then wrench-tightened an additional ¾ turn to complete the pressure seal. To remake an existing pressure fitting, install finger-tight and wrench-tighten just enough to achieve a seal. Overtightening an existing fitting may cause irreversible damage to the connector seat.

WARNING

Avoid making connections directly to the transmitter pressure fitting. Make connections to the buffer tube fitting wherever possible. If the transmitter pressure fitting becomes flared, stripped or damaged, it will be necessary to return the unit to Paroscientific for repairs.

WARNING

Do not remove the buffer tube. It is an integral part of the mechanical shock protection system of the transmitter.

For additional information, see the application note “The Use and Handling of Buffer Tubes” at www.paroscientific.com.

3.1.2 Oil Filled vs. Non-Oil Filled Units

OIL FILLED TRANSMITTERS

Transmitters intended for liquid media pressure measurements are oil filled at Paroscientific. Transmitters that are oil filled should never be used in gas media applications.

Oil-fill and bleed all pressure lines that are to be connected to an oil filled transmitter. The same oil used to fill the transmitter should be used to fill the pressure lines; consult the transmitter Specification Control Drawing for details.

CAUTION

If your transmitter and buffer tube are oil filled, do not pull a vacuum or apply pressurized gas to the unit. Doing so could allow bubbles to form in the pressure lines and transmitter, which will adversely affect the accuracy of the unit.

CAUTION

Pressure head effects result in zero offsets. These effects are more pronounced when liquid filled pressure lines are being used. These effects can be minimized by keeping the transmitter pressure port and the pressure source at the same elevation, or by making an offset correction to compensate for the pressure head.

NON-OIL FILLED TRANSMITTERS

Non-oil filled transmitters are intended for use in dry gas media applications, and should never be used in liquid media applications.

WARNING

If your transmitter and buffer tube are not oil-filled, do not apply pressurized liquid media to the unit. Liquid may contaminate the unit, and may adversely affect the accuracy of the unit. It is not possible to completely remove most liquids from the transmitter once they have been introduced.

For additional information, see the application note “Oil Filled Transducers Accuracy, Performance, and Handling” at www.paroscientific.com.

3.2 Quick Start

This section will help you to quickly connect your Digiquartz Intelligent device to the RS-232 serial port of a standard PC, establish communications, and take your first pressure measurements.

This process will be much simpler and easier if you have purchased a Power Module Kit. The kit specific to your device see below:

FOR DUAL RS-232 / RS-485

P/N 1294-001 (110VAC) or 1294-002 (220VAC):

- Power adapter module, P/N 6671-003
- 110 or 220 VAC wall power supply, P/N6377-001 or 6377-004
- 9-pin serial cable, P/N 6409-003

FOR RS-232 ONLY

P/N 1291-002 (110VAC) or 1291-002 (220VAC):

- Power adapter module, P/N 6671-0031
- 110 or 220 VAC wall power supply, P/N6024-001 or 6024-002

3.2.1 Connect Up the System

IF YOU HAVE THE POWER MODULE KIT:

- Connect up the system as shown in Figure 11-13 on page 91.
- Plug in the wall power supply.

IF YOU DON'T HAVE THE POWER MODULE KIT:

- Connect up the system as shown in Figure 11-14 on page 92.

3.2.2 Run Digiquartz Interactive 3 (DQI3)

- Install Digiquartz Interactive 3 (DQI3) on your Windows-based PC. DQI3 can be found at www.paroscientific.com. DQI3 is compatible with both 32 and 64-bit Windows operating systems.
- Connect the RS-232 port of your instrument to the serial communications port on your PC, and power up the instrument.
- Run DQI3, the start-up screen will be displayed as default.
- Under the *Configuration and Monitoring* option, select the COM port if known, otherwise select *All*.
- Click *Search For Devices*. DQI3 will attempt to detect the instrument, and if successful, will display its serial number and communications parameters.

NOTE: For users with multiple networked devices, select a single device under *Devices Detected* before proceeding. If the search ends and your instrument is not located, close DQI3 and ensure that your instrument is powered and properly connected to the PC serial communications port before running DQI3 again.

- Once the instrument is located, click *Go to Configuration and Monitoring* to setup parameters and begin taking measurements.

Congratulations, you are now ready to take your first pressure measurement! We encourage you to use DQI3 to explore the remaining functions of your Digiquartz Intelligent device. Please refer to the Help function in DQI3 and Section 4.6, page 26 for more information.

4 Operation

4.1 Compatible Serial Hardware

Digiquartz Intelligent devices are compatible with any equipment that conforms to the EIA RS-232 and/or RS-485 specifications. They are also backward compatible with earlier Intelligent devices that support RS-232 only, and can be used together in RS-232 serial loop networks.

Digiquartz Intelligent devices with RX.XX series firmware are only compatible with the Model 715 Display, and not with the older Model 710. Older Digiquartz Intelligent devices with SX.XX series firmware are only compatible with the older Model 710 Display, and not with the Model 715.

4.2 Serial and Power Connections

Serial and power connections are made via a 15-pin high-density D-Sub connector for dual RS-232/485 devices, or 9-pin D-Sub connector for RS-232 only devices. Refer to Section 11.1, page 85 for connector pin details, and Section 11.2, page 91 for detailed system wiring diagrams.

It is recommended that you establish communications and verify transmitter operation prior to permanently installing the device. The Power Module Kit simplifies the task of powering the transmitter and making serial connections to a PC or other serial host. Refer to Section 3.2, page 21 for details.

> **NOTE:** The Power Module Kits are intended for use with Digiquartz Intelligent transmitters, and are not compatible with Intelligent depth sensor products.

4.3 Communications

Digiquartz Intelligent devices are initially configured for RS-232/RS-485 communications at 9,600 baud. The serial protocol is fixed at 8 data bits, no parity, and 1 stop bit. Each Intelligent device has an ID number, and will only respond to commands sent to its ID number or 99. ID number 99 is reserved as a global address, which can be used to send a single command to multiple devices at once. The ID number is initially configured to 01, but you can set the ID number to any value between 01 and 98.

It is recommended that Digiquartz Interactive 3 (DQI3) software be used to establish initial communications with your transmitter. Refer to Section 3.2, page 21 for details.

You may also use any terminal program that is configured for the proper baud rate and serial protocol. Your terminal program must also send a line-feed character (ASCII 10) with each carriage return.

4.4 Command and Response Basics

ASCII text commands are used to communicate remotely with the device.

The following basic tasks can be performed by sending the appropriate command:

- Take a measurement
- Perform a control function, such as changing the baud rate
- Set or read the value of an operating parameter, such as integration time

Measurement commands typically generate a response that contains the measurement data. Parameter-set commands typically generate a response that reports the updated parameter value. Parameter-read commands report the current parameter value.

When setting virtually all parameter values, you must precede the command with an **EW** command. This reduces the likelihood of accidental alteration of stored parameter values. Please refer to Section 5.1, page 27 for more information about the **EW** command.

In general, when a command is being processed and another command is received, the device will abort the command in process and begin processing the second command, regardless of whether the commands are received via RS-232 or RS-485. However, when Fetch Mode is selected, measurement commands can typically be received simultaneously on the RS-232 and RS-485 ports, allowing asynchronous access to measurement data from two serial hosts. Refer to Section 2.3, page 14 and the **FM** command on page 44 for more information about Fetch Mode.

> **NOTE:** Due to internal resource limitations, commands sent simultaneously to both RS-232 and RS-485 ports may occasionally not generate a response. It is recommended that the serial host retry the command should this occur.

4.5 Command and Response Format

Commands sent to and responses received from the device are very similar, and are made up of the following:

START CHARACTER

The start character is an asterisk (ASCII 42).

DESTINATION ID

This is the Unit ID number of the device that is to receive the command or response. It is a two-digit integer between 00 and 99. ID 00 is reserved for the serial host, usually a PC. The factory default Unit ID number is 01.

SOURCE ID

This is the Unit ID number of device that is sending the command or the response. It is a two-digit integer between 00 and 98. ID 00 is reserved for the serial host, usually a PC.

COMMAND OR RESPONSE DATA

A wide variety of commands and resulting response data are possible, depending on the particular command used. Refer to Section 5 beginning on page 27 for descriptions of the entire command set.

TERMINATION CHARACTERS

All commands must terminate with a carriage return (ASCII 13 decimal) followed by a linefeed (ASCII 10 decimal). All command responses are terminated in the same manner.

COMMAND FORMAT

Commands are typically sent in the following format. The **P3** command is used in this example:

*0100P3CrLf

Where:

* = Start character	Asterisk, ASCII 42 decimal
01 = Destination ID	Unit ID of the device that is to receive the command.
00 = Source ID	Unit ID of the device that is sending the command (Serial host is ID 00)
P3 = Command	**P3** is an example. Refer to Section 5 for descriptions of the entire command set.
Cr = Carriage return	ASCII 13 decimal
Lf = Linefeed char.	ASCII 10 decimal

RESPONSE FORMAT

Responses are typically received in the following format:

*000114.4567CrLf

Where:

* = Start character	Asterisk, ASCII 42 decimal
00 = Destination ID	Unit ID of serial host that is to receive the response
01 = Source ID	Unit ID of device that is responding.
14.4567 = Data	Data sent in response to the prior command
Cr = Carriage return	ASCII 13 decimal
Lf = Linefeed char.	ASCII 10 decimal

These examples are typical, but other response forms exist. Refer to Section 5 for specific details regarding each available command.

4.6 Digiquartz Software

Paroscientific provides several software programs that simplify common measurement and configuration tasks. The latest versions of these and other software programs are available at the Paroscientific web site at www.paroscientific.com.

4.6.1 Digiquartz Interactive 3 (DQI3)

OVERVIEW

Digiquartz Interactive 3 (DQI3) is a Windows-based program that makes it easy to communicate with and configure Digiquartz Intelligent devices. We encourage you to install and use DQI3 to verify proper operation, configure your device, take measurements, and experiment with its functions. DQI3 supports both 32 and 64-bit operating systems.

DQI3 consists of two main sections: Configuration and Monitoring and Digiquartz Terminal.

CONFIGURATION AND MONITORING SECTION

The Configuration and Monitoring section allows one to set up a device and display measurement values without previous knowledge of device commands, as well as provide the advanced user with a powerful set of configuration tools.

With Configuration and Monitoring, you can:

- Establish communications with a device on any available com port, at any supported Unit ID and baud rate value.
- Perform common configuration functions.
- Store current configuration settings for future restoration needs.
- Save or print a configuration report.
- Save or print a diagnostic report.
- Take measurements and display measurement data.
- Plot measurement data and print graphs.
- Log time-stamped measurement data to a file for analysis.

DIGIQUARTZ TERMINAL SECTION

The Digiquartz Terminal section allows one to communicate directly with the device at the most fundamental level using native commands. All possible configuration and measurement functions are available via the terminal interface. Digiquartz Terminal is designed especially for communication with Digiquartz Intelligent devices.

HOW TO USE DQI3

Refer to Section 3.2.2, page 21 for basic installation instructions, and to the help function in DQI3 for more detailed information.

5 Command Instructions

5.1 Enable Write Command

When setting virtually all parameter values, you must precede the parameter set command with an **EW** (enable write) command. Parameter set commands will usually be ignored unless they are preceded with an **EW** command.

EW **Enable the next parameter set command to write a new value into non-volatile memory.**

EW can be issued as a separate command by terminating it with a carriage return/line feed, or you can string the EW and parameter set commands together, as shown below.

Typical Syntax:	*0100EW*0100TR=800
Alternate Syntax:	*0100EW
	*0100TR=800

NOTE: **EW** is only necessary when using commands to set a parameter value. It is not necessary to use **EW** to read a parameter value, or when using measurement commands.

5.2 Serial Communications Commands

The serial communications commands enable the baud rate and device ID to be set via the RS-232 or RS-485 ports.

BR **Set the baud rate.**

Default:	9600
Typical Command:	*9900BR=19200
Typical Response:	*9900BR=19200

BR is a set-only command. It is not possible to read the value of **BR. BR** must be sent to the global Unit ID 99. **BR** cannot be sent to an individual Unit ID. Supported baud rates are 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200 baud.

NOTE: Since **BR** is a global command, it produces no response on the RS-485 port.

NOTE: Under certain conditions, communication problems may occur at the 115200 baud rate. If the problem persists, consider changing the baud rate to a lower setting.

BL **Lock or unlock the baud rate.**

Typical Command: *9900EW*9900BL=1
Typical Response: *9900EW
*0001BL=1
*9900BL=1

BL is a set-only command. It is not possible to read the value of **BL. BL** must be sent to the global ID 99. **BL** cannot be sent to an individual unit ID. If the command was successful, the responses on the RS-232 port include the **EW** command echo and a **BL** command response for each unit - this is due to the nature of the serial loop networking protocol. If the command was unsuccessful, the response will only be the command sent.

NOTE: Since **BL** is a global command, it produces no response on the RS-485 port.

ID **Set the Unit ID. ID must be sent to the global ID 99.**

Typical Command: *9900ID
Typical Response: *9902ID

RS-232 USAGE - With a single unit, **ID** sets the Unit ID of the unit to the source ID + 1. When used with a serial loop network, **ID** sets the Unit ID of the first unit to the source ID + 1. The unit then responds by incrementing the source ID. This behavior enables **ID** to set all units on the serial loop network to unique Unit ID values in ascending order, starting with the command source ID + 1. See Section 8.4, page 76 for more information on serial loop networking.

RS-485 USAGE - Use of the **ID** command is not recommended in RS-485 multi-drop networks, since all the units on the network would be set to the same Unit ID. To set a unique Unit ID for each unit to be used in a multi-drop network, set them one at a time prior to installing them in the network. Refer to Section 8.3, page 74 for more information on RS-485 networking.

5.3 Measurement Commands

The following commands are used to initiate measurements, and to control measurement integration time.

5.3.1 Single Measurement Commands

The following commands are used to initiate single measurements. They return the resulting measurement value as soon as it is available when in Integration Mode, or immediately if in Fetch Mode. Refer to the **FM** command on page 44 for more information about Integration Mode and Fetch Mode.

P3 **Sample and send one pressure measurement.**

Action:	Measure pressure sensor temperature period and pressure period, calculate temperature-compensated pressure, send pressure value, and await next command.
Units:	As specified by **UN**
Typical Command:	*0100P3
Typical Response:	*00114.71234 (Value: 14.71234)

THE FOLLOWING ARE LOW-LEVEL MEASUREMENT COMMANDS GENERALLY USED FOR DIAGNOSTIC PURPOSES:

Q3 **Sample and send one pressure sensor temperature measurement.**

Action:	Measure internal pressure sensor temperature period, calculate pressure sensor temperature, send pressure sensor temperature value, and await next command.
Units:	°F or °C, as selected by **TU**
Typical Command:	*0100Q3
Typical Response:	*000122.345 (Value: 22.345)

NOTE: **Q3** is the internal pressure sensor temperature, and is mainly used for diagnostic purposes.

NOTE: Repeatedly issuing the **Q3** command will temporarily prevent the optional Model 715 display from being updated.

P1 **Sample and send one pressure period measurement.**

Action:	Measure pressure period, send pressure period value, and await next command.
Typical Command:	*0100P1
Typical Response:	*000128.123456 (Value: 28.123456)

NOTE: Repeatedly issuing the **P1** command will temporarily prevent the optional Model 715 display from being updated.

Q1 **Sample and send one pressure sensor temperature period measurement.**

Action:	Measure internal pressure sensor temperature period, send pressure sensor temperature period value, and await next command.
Units:	Microseconds
Typical Command:	*0100Q1
Typical Response:	*00015.1234567 (Value: 5.1234567)

NOTE: Repeatedly issuing the **Q1** command will temporarily prevent the optional Model 715 display from being updated.

5.3.2 Continuous Measurement Commands

The following commands are used to initiate and control continuous measurements. Continuous measurement commands repeatedly take measurement samples and return measurement values until commanded to stop (or power is interrupted). Continuous measurements are cancelled by sending any valid command.

P4 Continuously sample and send pressure measurement values.

Action:	Continuously sample and send pressure measurement values, and repeat until commanded to stop.
Units:	As specified by **UN**
Typical Command:	*0100P4
Typical Response:	*000114.71234 (Value: 14.71234) *000114.71235 (Value: 14.71235) *000114.71234... (Value: 14.71234)

P7 Continuously send high-speed pressure measurements.

Action:	Continuously sample and send pressure measurement values, using temperature measurement interval specified by the current value of **PS**. **P7** automatically performs the following sequence: 1. Initially measure temperature period. 2. Measure pressure period. 3. Calculate temperature compensated pressure using last temperature period measurement. 4. Send pressure value. 5. Do steps 2-4 the number of times specified by **PS**, then measure temperature period. 6. Repeat steps 2-5 until commanded to stop.
Units:	As specified by **UN**
Typical Command:	*0100P7
Typical Response:	*000114.71234 (Value: 14.71234) *000114.71235 (Value: 14.71235) *000114.71234... (Value: 14.71234)

NOTE: **P7** allows you to maximize the pressure sampling rate by taking temperature measurements at the interval specified by the **PS** command. Each subsequent pressure value is temperature-compensated using the currently stored temperature value. You can take a single initial temperature measurement, or you can take periodic temperature measurements at the interval you select with the **PS** command. Please refer to the **PS** command for more information.

NOTE: **P7** offers a performance advantage over **P4** only when in Sequential Integration Mode (**OI**=1). When in Simultaneous Integration Mode (**OI**=0), **P7** and **P4** are equivalent in terms of performance.

PS Set or read temperature measurement interval used by P7 command.

Range:	1 to 65535
Default:	0
Units:	Pressure measurements
Typical Command:	*0100EW*0100PS=4
Typical Response:	*0001PS=4

Controls how often temperature measurements are taken during a **P7** pressure measurement sequence.

If **PS**=0, an initial temperature measurement is taken, and all subsequent pressure measurements are compensated using that value.

If **PS**=1, a temperature measurement is taken before each pressure measurement (same as **P4**).

If **PS**=n and n>1, an initial temperature measurement is taken, and subsequent temperature measurements are taken after every n pressure measurements.

THE FOLLOWING ARE LOW-LEVEL MEASUREMENT COMMANDS GENERALLY USED FOR DIAGNOSTIC PURPOSES:

P2 Continuously sample and send pressure period measurement values.

Action:	Measure pressure period, send pressure period value, and repeat until commanded to stop.
Units:	Microseconds
Typical Command:	*0100P2
Typical Response:	*000128.123456 (Value: 28.123456) *000128.123457 (Value: 28.123457) *000128.123456 …(Value: 28.123456)

NOTE: The **P2** command will temporarily prevent the Model 715 display from being updated.

Q2 Continuously sample and send temperature period measurement values.

Action:	Measure internal pressure sensor temperature period, send temperature period value, and repeat until commanded to stop.
Units:	Microseconds
Typical Command:	*0100Q2
Typical Response:	*00015.1234567 (Value: 5.1234567) *00015.1234568 (Value: 5.1234568) *00015.1234567…(Value: 5.1234567)

NOTE: The **Q2** command will temporarily prevent the Model 715 display from being updated.

Q4 **Continuously sample and send temperature measurement values.**

Action:	Measure internal pressure sensor temperature period, calculate temperature, send temperature value, and repeat until commanded to stop.	
Units:	°F or °C, as selected by **TU**	
Typical Command:	*0100Q4	
Typical Response:	*000122.345	(Value: 22.345)
	*000122.346	(Value: 22.346)
	*000122.345 …	(Value: 22.345)

NOTE: The **Q4** command will temporarily prevent the Model 715 display from being updated.

5.3.3 Compound Measurement Commands

Compound measurement commands return multiple measurement values. They ensure the measurement values are acquired simultaneously, and are more efficient and convenient than taking the measurements separately.

Three compound measurements are available:

- Pressure and temperature
- Pressure period and temperature period
- Pressure, pressure period, and temperature period

Compound measurements can be either polled, continuous initiated by a command, or continuous whenever power is applied. Refer to the **MD** command on page 45 for compound commands that produce data whenever power is applied.

E1 **Sample and send one compound pressure period and temperature period measurement. Measurement values are formatted identically to P1 and Q1 commands.**

Action:	Take simultaneous pressure and temperature period measurements, send pressure and temperature period measurements, await next command.
Typical Command:	*0100E1
Typical Response:	*0001,30.142801,5.8120589

NOTE: Repeatedly issuing the E1 command will temporarily prevent the optional Model 715 display from being updated.

E2 **Continuously sample and send compound pressure period and temperature period measurements. Response data is formatted identically to E1.**

Action: Take simultaneous pressure and temperature period measurements, send pressure and temperature period measurements, continue until commanded to stop.
Typical Command: *0100E2
Typical Response: *0001,30.142801,5.8120589
*0001,30.142802,5.8120588
*0001,30.142803,5.8120587…

NOTE: NOTE: The E2 command will temporarily prevent the optional Model 715 display from being updated.

E3 **Sample and send one compound pressure and temperature measurement. Measurement values are formatted identically to P3 and Q3 commands.**

Action: Take simultaneous pressure and temperature period measurements, calculate temperature and temperature-compensated pressure value, send pressure and temperature values, await next command.
Typical Command: *0100E3
Typical Response: *0001,14.50629, 21.514

E4 **Continuously sample and send compound pressure and temperature measurements. Response data is formatted identically to E3.**

Action: Take simultaneous pressure and temperature period measurements, calculate temperature and temperature-compensated pressure value, send pressure and temperature values, continue until commanded to stop.
Typical Command: *0100E4
Typical Response: *0001,14.50629, 21.514
*0001,14.50630, 21.513
*0001,14.50631, 21.512…

E5 **Sample and send one compound pressure, pressure period, and temperature period measurement. Measurement values are formatted identically to P3, P1, and Q1 commands.**

Action: Take simultaneous pressure and temperature period measurements, calculate temperature-compensated pressure value, send pressure, pressure period, and temperature period values, await next command.
Typical Command: *0100E5
Typical Response: *0001,14.63820, 30.167999,5.8125361

E6 **Continuously sample and send compound pressure, pressure period, and temperature period measurements. Response data is formatted identically to E5.**

Action:	Take simultaneous pressure and temperature period measurements, calculate temperature-compensated pressure value, send pressure, pressure period, and temperature period values, continue until commanded to stop.
Typical Command:	*0100E6
Typical Response:	*0001,14.63820, 30.167999,5.8125361 *0001,14.63821, 30.167998,5.8125362 *0001,14.63822, 30.167997,5.8125363…

5.3.4 Sample and Hold Measurement Commands

The following commands are used to initiate and send single sample and hold measurements. Measurement values are held until the next command is received. If the next command is a **DB** or **DS** command, the measurement value is sent; if it is any other command, the measurement value is lost. If a **DB** or **DS** command is received before the measurement command is complete, the measurement value will be sent as soon as it is available.

⚠ CAUTION

Sample and hold commands will temporarily prevent the optional Model 715 display from being updated until the **DB** or **DS** command is received or the sample and hold command is cancelled by the next valid command.

P5 **Sample and hold one pressure measurement.**

Action:	Measure temperature period, measure pressure period, calculate temperature-compensated pressure, save pressure value, and await **DB** or **DS** command.
Units:	As specified by **UN**
Typical Command:	*0100P5
Typical Response:	No response until **DB** or **DS** command is received

DB **Dump Buffer. Send a held measurement value.**

Action:	If a measurement value is being held, send it - otherwise do nothing.
Typical Command:	*0100DB
Typical Response:	*000114.12345 (Value: 14.12345)

NOTE: The **DB** command can also be used globally on the RS-232 port. The device will not respond to a global **DB** command on the RS-485 port.

DS **Dump Sequential. Sequentially send a held measurement value.**

Action:	If a measurement value is being held, send it - otherwise do nothing.	
Typical Command:	*9900DS	
Typical Response:	*000114.12345	(From unit 1)
	*000214.54321	(From unit 2)
	*9900DS	(Echoed **DS** command)

DS is useful only when acquiring measurement data from two or more units in an RS-232 serial loop network. **DS** ensures that measurements are returned in the order that units appear in the serial loop network. See Section 8.4, page 76 for more information about RS-232 serial loop networking.

NOTE: **DS** is available with firmware version R3.00 and later. **DS** is only useful in RS-232 serial loop applications and returns measurement command responses in sequential order according to the location of devices on RS-232 serial loop.

THE FOLLOWING ARE LOW-LEVEL MEASUREMENT COMMANDS GENERALLY USED FOR DIAGNOSTIC PURPOSES:

P6 **Sample and hold one pressure period measurement.**

Action:	Measure pressure period, save pressure period value, and await **DB** or **DS** command.
Units:	Microseconds
Typical Command:	*0100P6
Typical Response:	No response until **DB** or **DS** command is received

Q5 **Sample and hold one pressure sensor temperature measurement.**

Action:	Measure internal pressure sensor temperature period, calculate pressure sensor temperature, save value, and await **DB** or **DS** command.
Units:	°F or °C, as selected by **TU**
Typical Command:	*0100Q5
Typical Response:	No response until **DB** or **DS** command is received

Q6 **Sample and hold one pressure sensor temperature period measurement.**

Action:	Measure pressure sensor temperature period, save value, and await **DB** or **DS** command.
Units:	Microseconds
Typical Command:	*0100Q6
Typical Response:	No response until **DB** or **DS** command is received

5.4 Measurement Integration Time Commands

Digiquartz Intelligent devices support time-based pressure integration only. This means that the unit's pressure and temperature signals are sampled for a user-specified period of time. In the past, period-based integration was also supported, which sampled the pressure and temperature signals for a user-specified number of periods. For backward compatibility, the commands that once controlled period-based integration (**PR** and **TR**) are still supported, but the assigned values are internally converted to equivalent time-based values.

See Section 7.1, page 69 for information regarding the relationships between integration time, resolution, and sampling rate.

TIME-BASED INTEGRATION

PI and **TI** are the time-based integration time commands for pressure and temperature signal integration. The advantage of **PI** and **TI** is that the integration time is not a function of measured period, and is consistent from unit to unit. This allows you to synchronize measurements from two or more Digiquartz Intelligent devices that support time-based integration. The resolution of **PI** and **TI** is approximately 1ms.

PERIOD-BASED INTEGRATION

PR and **TR** are the period-based integration time commands for pressure and temperature signal integration. **PR** and **TR** have been made obsolete by **PI** and **TI**, but remain available for compatibility with older units. The resolution of **PR** is approximately 3ms, and **TR** is approximately 1ms.

> **NOTE:** When Simultaneous Integration is selected, the pressure and temperature signals are integrated simultaneously, resulting in faster data rates at a given pressure resolution. In this case, the time needed to acquire a pressure measurement is controlled by the greater of the pressure and temperature integration times. Refer to Sections 2.3, 5.7, and 7.1 for more information about Simultaneous Integration.

TIME-BASED INTEGRATION TIME COMMANDS

PI **Set or read time-based pressure measurement integration time.**

Units:	Milliseconds (Resolution = 1 millisecond)
Range:	1 to 290000 when **XM** = 0
	1 to 72500 when **XM** = 1
Default:	666
Typ. Set Command:	*0100EW*0100PI=1000
Typ. Set Response:	*0001PI=1000
Typ. Read Command:	*0100PI
Typ. Read Response:	*0001PI=1000

> **NOTE:** Do not set **PI** to a value < 10 when using a Model 715 display, as doing so may result in an inconsistent display.

TI **Set or read time-based temperature measurement integration time.**

Units:	Milliseconds (Resolution = 1 millisecond)
Range:	1 to 290000 when **XM** = 0
	1 to 72500 when **XM** = 1
Default:	666
Typ. Set Command:	*0100EW*0100TI=1000
Typ. Set Response:	*0001TI=1000
Typ. Read Command:	*0100TI
Typ. Read Response:	*0001TI=1000

NOTE: Whenever the value of **PI** is changed, **TI** is automatically updated with the same value. Changing **TI** has no effect on **PI**. **TI** should be set to the same value as **PI** for optimum performance in most applications.

PERIOD-BASED INTEGRATION TIME COMMANDS

NOTE: These are obsolete legacy commands that have been replaced by time-based integration commands **PI** and **TI**.

PR **Set or read period-based pressure measurement integration time.**

Range:	1 to 16383
Default:	238
Typ. Set Command:	*0100EW*0100PR=200
Typ. Set Response:	*0001PR=200
Typ. Read Command:	*0100PR
Typ. Read Response:	*0001PR=200

NOTE: Do not set **PR** to a value < 10 when using a Model 715 display, as doing so may result in an inconsistent display.

TR **Set or read period-based temperature measurement integration time.**

Range:	1 to 65535
Default:	952
Typ. Set Command:	*0100EW*0100TR=800
Typ. Set Response:	*0001TR=800
Typ. Read Command:	*0100TR
Typ. Read Response:	*0001TR=800

NOTE: Whenever the value of **PR** is changed, **TR** is automatically updated with value of **PR** times 4. Changing **TR** has no effect on **PR**. **TR** should be set to 4 times the value of **PR** for optimum performance in most applications.

5.5 Precise Measurement Time Interval Command

The **TH** command is used in conjunction with the continuous measurement commands to produce measurements at precise data rates. This can be useful in many applications, such as when measurements are to be analyzed in the frequency domain, or whenever the time between measurements must be known and consistent.

TH is an alternative to the **PI** command. **TH** specifies data rate rather than integration time, and results in a more accurate and consistent data rate compared to **PI**. The value of **TH** specifies the data rate in Hertz, over a range of 1Hz to 180Hz. If data rates less than 1 Hz are required, **PI** must be used.

The function of the **TH** command differs slightly depending on whether Standard or Nano-Resolution is selected:

Standard Resolution - In Standard Resolution mode, **TH** controls both resolution and data rate. When **TH** is nonzero, the data rate in Hz is specified by the value of **TH**, and **PI** is automatically optimized for the maximum resolution available at the specified data rate. When **TH** is set to 0, control of integration time and data rate revert back to **PI**.

Nano-Resolution - In Nano-Resolution mode, **TH** controls data rate only - resolution is set using the **IA** command. When **TH** is nonzero, the data rate in Hz is specified by the value of **TH**. When **TH** is set to 0, control of data rate reverts back to **PI**.

NOTE: See Section 6 for more information on using Nano-Resolution.

TH works only with the following continuous measurement commands: **P2, P4, P7, Q2, Q4, E2, E4, E6, MD**=2**, MD**=3**, MD**=6, **MD**=7, **MD**=14**,** and **MD**=15. **TH** has no effect on polled and sample-and-hold measurement commands in standard resolution mode; they use **PI** to set the integration time regardless of the **TH** value.

Whether the desired data rate is attainable depends on serial baud rate and the number of characters in the measurement command response. When **TH** is set, the user specifies the intended measurement command. The unit then checks various parameter settings that affect data rate, and reports whether the specified data rate can be attained. For this reason, it is important that the unit be set to the desired baud rate and configured for the desired measurement prior to setting **TH**. It is also important to set **TH** again if a different measurement command is to be used, or if a configuration change results in a greater number of characters in the serial response.

TH Set or read measurement data rate.

Units:	Hertz (Hz)
Range:	1 to 180
Default:	0 (TH off; control reverts to PI)
Typ. Set Command:	*0100EW*0100TH=20,P4
Typ. Set Response:	*0001TH=20,P4;>OK
Typ. Read Command:	*0100TH
Typ. Read Response:	*0001TH=20

Example 1: Successfully setting data rate

For the Typical Set Command above, we will assume the user wants to acquire continuous pressure data (P4) at 20 Hz. The baud rate is currently set to 9,600 baud.

The >OK in the typical set response indicates the desired 20Hz data rate is attainable under the current conditions. Now, when the **P4** command is used, measurement data will be sent at 0.05 second intervals, or 20Hz.

Example 2: Unsuccessfully setting data rate

For this example, we will assume the user wants to acquire continuous pressure data (**P4**) at 40Hz. The baud rate is currently set to 9,600 baud.

Command:	*0100EW*0100TH=40,P4
Response:	*0001TH=40,P4;>ERROR

The >ERROR in the response indicates the desired 40Hz data rate is not attainable under the current conditions, and the value of **TH** was not updated. Generally, to correct the problem, one would either reduce the desired data rate or increase the baud rate.

Example 3: Returning control of integration time to PI

For this example, we will assume the user no longer requires precise measurement intervals and wishes to return control of integration time to **PI**. Note that it is not necessary to specify the measurement command when setting **TH** to zero.

Command:	*0100EW*0100TH=0
Response:	*0001TH=0

NOTE: **OF** command is not available when using the **TH** command.

5.6 User-Defined Commands

The user-defined commands enable the user to define custom commands. All measurement options are available. Any combination of measurement options and text can be specified, and measurement values can be formatted per your specifications.

User-defined commands consist of an output mask command to define the command behavior, and an associated command to execute the output mask. Three independent user-defined commands are available. To use a user-defined command, the output mask must be defined using the **OM** command. The output mask typically contains some combination of command codes, text strings, and numeric format specifiers, each separated by a comma. The **OF** command is used to execute the command defined by **OM**.

COMMAND CODES

Command codes are used in the output mask to produce measurement or text output when executed. The available command codes are listed in Table 5-1.

> **NOTE:** To work with a serial loop network, the output mask must begin with a STAR command code, and the second and third characters of the resulting response data must not match the address of any intelligent devices on the serial loop network.

TEXT STRINGS

Text strings are literal text delimited by quote characters. They can be inserted at any location within the output mask. The most common use of text strings is to annotate command code outputs.

> **Example:** "This is my text" will output "This is my text" (less the quote characters) when executed.

NUMERIC FORMAT SPECIFIERS

Numeric format specifiers are used to control the format of measurement value outputs. Command codes used with numeric format specifiers are identified in Table 5-1. Numeric format specifiers are placed immediately after the command code to which they apply.

Numeric format specifiers have syntax x.y, where x is any number between 0 and 9, and y is any number between 0 and 13.

The x value specifies the number of digits to the left of the decimal point that will be output. All digits to the left of the decimal point are always output regardless of the x value. If the x value is greater than the number of digits to the left of the decimal point, the output will be padded with leading zeros.

The y value specifies the number of digits to the right of the decimal point that will be output. If the y value is less than the number of digits to the right of the decimal point, the output will be rounded to the number of digits specified. If the y value is greater than the number of digits to the right of the decimal point, the output will be padded with trailing zeros. Refer to Table 5-2 for examples.

TABLE 5-1: Command Codes For User-Defined Commands

Command Code	Description	Format Specifier?
P	Pressure	Y
P+	Add sign character to pressure value	Y
MINP	Minimum pressure	Y
MAXP	Maximum pressure	Y
TV	Tare value	N
ST	Sensor temperature	Y
PPER	Pressure period	Y
TPER	Temperature period	Y
PU	Pressure unit	N
TU	Sensor temperature unit	N
UA	Destination ID	N
HA	Source ID	N
HEAD	Same as STAR,UA,HA	N
CR	Carriage return	N
LF	Line feed	N
CRLF	Carriage return/line feed	N
STAR	Asterisk	N
SPACE	Space character	N
COMMA	Comma character	N
RESET	Set mask to default (must be used alone)	N

NOTE: Command codes in Table 5-1 are not case sensitive.

TABLE 5-2: User-Defined Numeric Formatting Examples

Value	Output Mask	Output
14.56789	P1.5	14.56789
14.56789	MIN5.5	00014.56789
14.56789	MAX2.2	14.57
14.56789	P2.7	14.5678900
14.56789	P5.7	00014.5678900

OM Set or read the user-defined command output mask.

Three output masks can be defined - **OM1**, **OM2**, and **OM3**. The number is optional - if no number is specified, **OM1** is assumed.

Range:	200 characters maximum.
Default:	OM1=STAR,HA,UA,P,CRLF OM2=HEAD,SPC,P,SPC,PU,COMMA,TEMP,"C", COMMA,RH,"%",END OM3=S,"P3:",P,SPC,PU,COMMA,"TT:",TEMP, "C",COMMA,"RH:",RH,"%",COMMA,TIME, SPC,DATE,E
Typ. Set Command:	*0100EW*0100OM="Pressure:",P,CRLF
Typ. Set Response:	*0001OM="Pressure:",P,CRLF
Typ. Read Command:	*0100OM
Typ. Read Response:	*0001OM="Pressure:",P,CRLF

When the **OM** command is sent, the output mask is checked for syntax errors. If a syntax error is detected, an error code is returned, along with the output mask up to the point where the error was detected. The syntax error will be between the last comma and the end of the returned output mask. Refer to Table 5-3 for list of **OM** error codes and their descriptions.

TABLE 5-3: OM Command Error Codes

OM Error Code3	Description
O1	Unrecognized command
O2	Missing quote character
O3	Output mask too long
O4	RESET mixed with other command codes
O5	Bad format specifier

OF Executes the associated user-defined command output mask.

OF1, **OF2**, and **OF3** execute output masks defined by **OM1**, **OM2**, and **OM3**, respectively. The number is optional - if no number is specified **OF1** is assumed. **OFR** will execute **OM** repeatedly until stopped. See **MD** to automatically execute on start-up.

Typical Command:	*0100OF
Typical Response:	Pressure: 14.12345

The **OF** command processes command codes in the order that they appear in the output mask. The output for each command code is sent as it is processed.

TABLE 5-4: Single Response, OM /OF Examples

OM Output Mask	OF Command Result
OM = STAR,HA,UA,P,"psi"	*000114.5678 psi
OM = HEAD,P,END	*000114.5678<CRLF>
OM = HEAD,P2.2,END	*000114.57<CRLF>
OM = "Min:",MINP,SPACE,"Max:",MAXP	Min: 14.5678 Max: 14.5687

TABLE 5-5: Continuous Response OM / OFR Examples

OM Output Mask	OFR Command Result
OM = STAR,HA,UA,P,"psi",CRLF	*000114.5678psi<CRLF> *000114.5678psi<CRLF> *000114.5678psi<CRLF>... ... ...

5.7 Measurement Mode Commands

Pressure measurement mode commands control the way the Intelligent device acquires pressure measurements.

OI **Select Sequential or Simultaneous pressure integration**

Action: The **OI** command is used to select Simultaneous Integration or Sequential Integration Simulation. When Simultaneous Integration is selected, the pressure and temperature periods are integrated simultaneously, resulting in increased data rates without sacrificing measurement resolution. When Sequential Integration Simulation is selected, the pressure and temperature periods are still integrated simultaneously, but the measurement timing is similar to units that only support Sequential Integration (firmware versions prior to R4.00).

Values: 0 = Simultaneous Integration
1 = Sequential Integration (**OI** resets to 0 when **XM**=1)

Default: 1

Typ. Set Command: *0100EW*0100OI=1

Typ. Set Response: *0001OI=1

Typ. Read Command: *0100OI

Typ. Read Response: *0001OI=1

NOTE: When Simultaneous Integration is selected, the total integration time is equal to either the pressure (**PI**) or temperature (**TI**) integration time, whichever is greater. When Sequential Integration Simulation is selected, the total integration time is equal to the sum of the pressure (**PI**) and temperature (**TI**) integration times. Refer to Section 2.3, page 14 for more information about Simultaneous Integration, Sequential Integration, and Sequential Integration Simulation.

FM **Set or read Fetch Mode enable**

Action:	The **FM** command is used to select Integration Mode or Fetch Mode. When in Integration Mode, the unit initiates a new pressure measurement when the measurement command is received. This is the mode in which Digiquartz Intelligent devices have traditionally operated. In Fetch Mode, pressure measurement data is continuously acquired in the background, and the unit responds immediately to pressure measurement commands with the most recent measurement value. Fetch Mode also enables measurement commands to be processed simultaneously on both RS-232 and RS-485 ports. Refer to Section 2.3, page 14 for more information.
Values:	0 = Unit operates in Integration Mode 1 = Unit operates in Fetch Mode
Default:	0
Typ. Set Command:	*0100EW*0100FM=1
Typ. Set Response:	*0001FM=1
Typ. Read Command:	*0100FM
Typ. Read Response:	*0001FM=1

NOTE: When in Fetch Mode, it is not possible to enter Sleep Mode (**SL**).

5.8 Minimum/Maximum Pressure Commands

The Minimum/Maximum Pressure Commands return the minimum and maximum pressure measurement values.

M1 **Return minimum pressure measurement value**

Units:	Current pressure unit
Typ. Read Command:	*0100M1
Typ. Read Response:	*0001M1=14.12345 (Value: 14.54321)

M3 **Return minimum pressure measurement value**

Units:	Current pressure unit
Typ. Read Command:	*0100M3
Typ. Read Response:	*0001M3=14.12345 (Value: 14.54321)

MR **Reset the minimum and maximum pressure measurement values**

Units:	Current pressure unit
Typical Command:	*0100MR
Typical Response:	*0001MR>OK

When the **MR** command is received, the minimum and maximum pressure values will be set to the next pressure measurement value.

NOTE: **M1** and **M3** also reset to the next pressure measurement value whenever power is cycled, tare is initiated or disabled, or coefficients parameters that effect the pressure value are changed (**C1**, **C2**, **C3**, **D1**, **D2**, **PA**, **PM**, **TC**, **T1**, **T2**, **T3**, **T4**, **T5**, **U0**, **Y1**, **Y2**, **Y3**).

5.9 Serial Data Output Mode Command

The following command controls whether pressure data is continuously output, and whether display data are produced.

MD **Set or read the data output mode.**

Action:	**MD** configures the Intelligent Device for continuous pressure measurement output and/or display data output whenever power is applied.
Range:	0 - 3 (refer to Table 5-6 below)
Default:	1
Typ. Set Command:	*0100EW*0100MD=1
Typ. Set Response:	*0001MD=1
Typ. Read Command:	*0100MD
Typ. Read Response:	*0001MD=1

TABLE 5-6: MD Command Options

MD Value	Model 715 Display Data Output	Continuous Serial Data Command Output
0	OFF	None
1	ON	None
2	OFF	P3
3	ON	P3
8	OFF	OM1
10	OFF	OM2
12	OFF	OM3
14	OFF	E3
15	OFF	E5

CAUTION

Do not configure any device on a 2-wire RS-485 network for continuous pressure data output from the RS-485 port on power-up (**MD**=2, 3, 8, 10, 12, 14, or 15; **DO**=1). If you do this, it is unlikely that you will be able to reconfigure the unit over the network, since any command is likely to collide with the pressure data being continuously sent. To recover, you will need to remove the device from the network and reconfigure it individually via the RS-232 port.

When **MD** is set to a non-zero value, the specified serial data output mode will be preempted under the following conditions:

- When the intelligent device is running in a continuous pressure data output mode, continuous data output is suspended when a measurement command is received. Continuous data output resumes when the measurement command is complete.
- When the intelligent device is running in a display data output mode, display data output is suspended when a period measurement command (**P1, P2, P6, Q1, Q2, Q6**) is received. Display data output resumes when the period measurement command is complete.
- Continuous pressure data output is suspended when a continuous measurement command (**P2, P4, P7, Q2, Q4**) is received, and resumes when the continuous measurement command is cancelled.
- Once **MD** is set, the specified function will remain in effect until **MD** is set to a different value, even through a power cycle. Therefore, the Intelligent device will generally perform the specified function whenever power is applied.

NOTE: The **DO** command selects serial port to output data (RS-232 or RS-485). Refer to Section 5.15, page 57 for using the **DO** command.

5.10 Unit Commands

Unit commands are used to specify the engineering unit to be used when calculating pressure or sensor temperature values, and to configure the user-defined pressure unit.

UN **Set or read the pressure unit.**

Action:	Sets or reads the unit of all pressure values displayed and output via the serial ports.
Range:	0 to 8 (refer to Table 5-7).
Default:	1
Typ. Set Command:	*0100EW*0100UN=2
Typ. Set Response:	*0001UN=2
Typ. Read Command:	*0100UN
Typ. Read Response:	*0001UN=2

TABLE 5-7: Pressure Units and Conversion Factors

UN Value	Pressure Unit	Conversion Factor
0	User -defined pressure unit	Value of UF
1	psi	1.0000000
2	hPa (mbar)	68.94757
3	bar	0.06894757
4	kPa	6.894757
5	MPa	0.00689476
6	in Hg	2.036021
7	mmHg (Torr)	51.71493
8	m H_20	0.7030696

Setting **UN** to a non-zero value selects one of eight standard pressure units. Setting **UN** to 0 selects a user-defined unit whose conversion factor is specified by the **UF** command. **UN** also sets the units of pressure data displayed by an optional Model 715 display.

The native pressure unit of the device is psi. When a different pressure unit is specified, the pressure value in psi is first calculated, and then converted to the desired unit by multiplying by the appropriate conversion factor.

UF Set or read the user-defined pressure unit conversion factor.

Action:	When **UN**=0, calculated pressure values in psi are multiplied by the value of **UF** before being output, thus scaling pressure values in the desired user-defined pressure unit.
Range:	-9999999 to 9999999
Default:	1.000000
Typ. Set Command:	*0100EW*0100UF=2
Typ. Set Response:	*0001UF=2.000000
Typ. Read Command:	*0100UF
Typ. Read Response:	*0001UF=2.000000

TU **Set or read the sensor temperature unit.**

Action:	Specifies the temperature units for **E3**, **E4**, **Q3**, **Q4**, **Q5**, and temperature data displayed by optional Model 715.
Range:	0 = °C 1 = °F
Default:	0
Typ. Set Command:	*0100EW*0100TU=1
Typ. Set Response:	*0001TU=1
Typ. Read Command:	*0100TU
Typ. Read Response:	*0001TU=1

NOTE: Temperature is always calculated in °C but converted to °F when **TU** = 1.

5.11 Power Management Commands

Digiquartz Intelligent devices can be commanded to enter a reduced-power Sleep Mode during periods of serial port inactivity. The unit "awakens" 0.6 seconds after a single serial character is received on either port. Since the unit is "asleep" when the wake-up character is received, that character will be lost, and will not be interpreted as being part of a command. It is therefore necessary to send a character and wait at least 0.6 seconds before sending a command to an Intelligent device that is in Sleep Mode.

CAUTION

Power management features are not available if **MD** is set for continuous output (**MD**>0) or Fetch Mode is enabled (**FM**=1).

SL **Set or read the sleep mode enable state.**

Action:	Allows sleep mode to be enabled or disabled. When sleep mode is enabled, the device will enter sleep mode when both serial ports have received no characters for the number of seconds specified by the value of **ST**. When sleep mode is disabled, the device cannot enter sleep mode.
Range:	0 = sleep mode disabled 1 = sleep mode enabled
Default:	0
Typ. Set Command:	*0100EW*0100SL=1
Typ. Set Response:	*0001SL=1
Typ. Read Command:	*0100SL
Typ. Read Response:	*0001SL=1

NOTE: **SL** is not available with continuous pressure output or nano-resolution.

ST **Set or read the sleep mode timeout length.**

Action:	When **SL**=1, the device enters sleep mode if both serial ports have received no characters for **ST** seconds.
Units:	Seconds
Range:	5 to 255, integer values only.
Default:	10
Typ. Set Command:	*0100EW*0100ST=5
Typ. Set Response:	*0001ST=5
Typ. Read Command:	*0100ST
Typ. Read Response:	*0001ST=5

5.12 Tare and Overpressure Commands

Tare is the process of subtracting a specified value from pressure measurements. You may use the current measured pressure as the tare value, or you may specify any desired value. Tare can also be enabled, disabled, and locked out through the use of serial commands. Serial pressure measurement data can be formatted to include an indication when tare is in effect. Refer to the **ZI** command on page 53 for more information.

The overpressure command can be used to specify the overpressure alarm setpoint. When the overpressure setpoint is exceeded, the overpressure I/O line changes from logic low (0 VDC) to logic high (3.3 VDC). Refer to Section 10, page 83 for more information.

Available tare options include:

Standard Tare - The default tare mode defaults the tare value to zero on power-up.

Non-Volatile Tare - Tare can optionally default to the last tare value on power-up, effectively retaining the tare value through a power cycle.

ZE **Set or read the tare mode**

Action:	When **ZE**=0, the value of **XV** (tare value) is set to zero on power-up. When **ZE**=1, the value of **ZV** is restored to the last tare value on power-up.
Range:	0 or 1
Default:	0
Typ. Set Command:	*0100EW*0100ZE=1
Typ. Set Response:	*0001ZE=1
Typ. Read Command:	*0100ZE
Typ. Read Response:	*0001ZE=1

ZS **Set or read the tare state parameter value.**

ZS is set to 0 on power-up. If **ZL**=0 (tare is not locked out), tare can be requested by setting the **ZS** to 1.

At the first pressure measurement following a tare request, the following sequence occurs:

1. Pressure value is stored in the **ZV** parameter.
2. Value of **ZS** is set to 2 to indicate that tare is in effect.
3. Value of **ZV** is subtracted from all subsequent pressure values until tare is turned off.

If tare is already in effect when a **ZS**=1 command is issued, the sequence described above occurs at the next pressure measurement, and tare continues using a new value of **ZV**.

Tare can be turned off by issuing a **ZS**=0 command.

Action:	The three states of **ZS** are as follows: **ZS**=0, tare function is off. **ZS**=1, tare requested, but is not yet in effect. **ZS**=2, tare is in effect
Range:	0 to 2
Default:	0
Typ. Set Command:	*0100EW*0100ZS=1
Typ. Set Response:	*0001ZS=1
Typ. Read Command:	*0100ZS
Typ. Read Response:	*0001ZS=1

ZV **Set or read the tare value.**

Action:	Sets or reads the value that is subtracted from pressure measurements when tare is activated. **ZV** can be set to any desired value when tare is in effect (**ZS**=2). Note, however, that if tare is subsequently requested, a new value will overwrite the **ZV** value you have set. The value of **ZV** =0 on power-up.
Range:	-9999999 to 9999999
Default:	0
Typ. Set Command:	*0100EW*0100ZV=14.7123
Typ. Set Response:	*0001ZV=14.7123
Typ. Read Command:	*0100ZV
Typ. Read Response:	*0001ZV=14.7123

ZL **Set or read the tare lockout parameter value.**

Action:	When **ZL**=0, **ZS** can be set to enable and disable tare. When **ZL**=1, tare is locked, and the value of **ZS** cannot be modified via serial commands or the Tare Input I/O line. However, if **ZS**=1 and a **ZL**=1 command is issued, tare will be in effect when the next pressure measurement is taken, but you cannot turn tare off until **ZL** is set to 0. The value of **ZL** is set to 0 on power-up.
Range:	0 or 1
Default:	0
Typ. Set Command:	*0100EW*0100ZL=1
Typ. Set Response:	*0001ZL=1
Typ. Read Command:	*0100ZL
Typ. Read Response:	*0001ZL=1

OP **Set or read the overpressure alarm setpoint value.**

Action:	When a pressure measurement value is less than the value of **OP**, the Overpressure I/O line is at logic low (0 VDC); if it is greater or equal to the value of **OP**, the Overpressure I/O line is set to logic high (3.3 V DC). Refer to Section 10, page 83 for more information. **OP** is set in the current pressure units, and is scaled accordingly if the engineering units are changed.
Range:	-9999999 to 9999999
Default:	Maximum rated device pressure
Typ. Set Command:	*0100EW*0100OP=15
Typ. Set Response:	*0001OP=15.00000
Typ. Read Command:	*0100OP
Typ. Read Response:	*0001OP=15.00000

NOTE: Command **OP** only checks for overpressure when **MD** is not = 0 or during pressure readings (**P3** or **P4**). Refer to Section 5.9, page 45 for more on the **MD** command.

NOTE: The Model 715 displays an overpressure message based on the **PL** setting (absolute overpressure setpoint) that is independent of the **OP** setting (user overpressure setpoint). Refer to page 58 for more information on using the **PL** command.

5.13 Measurement Data Formatting Commands

These commands are used to alter the format of serial measurement data. The following data formatting functions are available:

- Append an engineering unit label to measurement data.
- Append an tare indication to tare pressure measurement data.
- Add underscores to separate the measurement data from the rest of the serial output data string to improve readability.
- Add trailing zeroes to the measurement data to create a fixed-length data string to simplify parsing.

Formatting commands can be used separately or in any combination.

US **Set or read the engineering units suffix parameter value.**

Action:	When **US**=1, a unit label is appended to measurement data. When **US**=0, no unit label is appended.
Range:	0 or 1
Default:	0
Typ. Set Command:	*0100EW*0100US=1
Typ. Set Response:	*0001US =1
Typ. Read Command:	*0100US
Typ. Read Response:	*0001US =1

Examples:

*000114.71234psia	(Pressure measurement, **US**=1)
*000121.123C	(Temp measurement, **US**=1)

When **US**=1, a pressure unit label is appended to pressure measurement values according to the value of **UN**:

TABLE 5-8: Appended Pressure Measurement Labels

UN value	Label
0	Defined by UM
1	psia, psig, or psid
2	hPa
3	bar
4	kPa
5	MPa
6	inHg
7	mmHg
8	mH2O

When **US**=1, a temperature unit label is appended to temperature measurement values according to the value of **TU**:

TABLE 5-9: Appended Temperature Measurement Labels

TU value	Label
0	C
1	F

SU **Set or read the underscore separator parameter value.**

Action: When **SU**=1, an underscore separates the measurement data from the address header and the optional unit suffix. When **SU**=0, no underscore separators appear.
Range: 0 or 1
Default: 0
Typ. Set Command: *0100EW*0100SU=1
Typ. Set Response: *0001SU=1
Typ. Read Command: *0100SU
Typ. Read Response: *0001SU=1

Examples:
*000114.71234 (**SU**=0)
*0001_14.71234 (**SU**=1)
*0001_14.71234_psia (**SU**=1, **US**=1)

ZI **Set or read the tare indication parameter value.**

Action: When **ZI**=1, a "T" is appended to pressure measurement values when tare is in effect. When **ZI**=0, no tare indication appears, whether tare is in effect or not.
Range: 0 or 1
Default: 0
Typ. Set Command: *0100EW*0100ZI=1
Typ. Set Response: *0001ZI=1
Typ. Read Command: *0100ZI
Typ. Read Response: *0001ZI=1

Examples:
*000114.71234 (**ZI**=0)
*000114.71234T (**ZI**=1)
*0001_14.71234T (**ZI**=1, **SU**=1)
*000114.71234Tpsia (**ZI**=1, **US**=1)
*0001_14.71234T_psia(**ZI**=1,**US**=1, **SU**=1)

DL **Set or read the fixed field data format parameter.**

Action:	When **DL**=1, measurement data is formatted in a fixed field format. When **DL**=0, measurement data is given in the standard format. The fixed field format is specified as follows: *AAAASDDDDDDDDDD (**XM**=0) *AAAASDDDDDDDDDDDDD (**XM**=1), where * = the asterisk character A = destination and source address characters S = sign of measurement data, either + or – D = numeric representation of measurement data, either digits or a decimal point
Range:	0 or 1
Default:	0
Typ. Set Command:	*0100EW*0100DL=1
Typ. Set Response:	*0001DL=1
Typ. Read Command:	*0100DL
Typ. Read Response:	*0001DL=1

Examples:		
	*000114.71234	(Pressure, **DL**=0)
	*0001+14.7123400	(Pressure, **DL**=1)
	*000121. 123	(Temperature, **DL**=0)
	*0001+21.1230000	(Temperature, **DL**=1)

NOTE: Period measurement data will contain no sign.

NOTE: The format specification and examples shown above assume that the other formatting commands are disabled. If other formatting commands are used in combination with **DL**, a fixed field format will still result, but the format will vary slightly from the one described above.

UM **Set or read the user-defined unit label parameter.**

Action:	When **UN**=0 and **US**=1, the text value of **UM** is appended to pressure measurements.
Range:	Any text up to four characters, consisting of ASCII 32 to ASCII 127.
Default:	user
Typ. Set Command:	*0100EW*0100UM=test
Typ. Set Response:	*0001UM=test
Typ. Read Command:	*0100UM
Typ. Read Response:	*0001UM=test

Examples:		
	*000114.71234	(**UN**=0, **US**=0)
	*000114.71234user	(**UN**=0,**US**=1, **UM**=user)

5.14 Unit Identification Commands

The Unit Identification commands read various unit-specific parameters. These parameters are factory-set, and cannot be modified.

SN **Read the serial number.**

Action: The **SN** parameter contains the device serial number. **SN** is a read-only command.
Typ. Read Command: *0100SN
Typ. Read Response: *0001SN=12345

VR **Read the firmware version number.**

Action: The **VR** parameter contains the device firmware version number. **VR** is a read-only command.
Typ. Read Command: *0100VR
Typ. Read Response: *0001VR=R5.10

CF **Read the firmware checksum.**

Action: The **CF** parameter contains the firmware checksum. The value of **CF** is always 4 characters. **CF** is a read-only command.
Typ. Read Command: *0100CF
Typ. Read Response: *0001CF=A1B2

MN **Read the model number.**

Action: The **MN** parameter contains the device model number as a text string. The value of **MN** always contains 24 characters. If the model number is less than 24 characters, the string will be padded with trailing spaces to a length of 24 characters. **MN** is a read-only command.
Typ. Read Command: *0100MN
Typ. Read Response: *0001MN=6030A

PF **Read the full-scale pressure value.**

Action: The **PF** parameter contains the full-scale pressure value in the current pressure units. If the units are changed, the value of **PF** is scaled accordingly. **PF** is a read-only command.
Typ. Read Command: *0100PF
Typ. Read Response: *0001PF=16.00000

PO **Read the pressure transducer type.**

Action: The **PO** parameter contains the pressure transducer type. **PO** is a read-only command.
Typ. Read Command: *0100PO
Typ. Read Response: *0001PO=0

TABLE 5-10: PO Value

PO value	Transducer type
0	Absolute
1	Gauge
2	Differential

5.15 Model 715 Display Configuration Commands

The Display Configuration commands allow you to control the information shown on the optional Model 715 display.

DM **Set or read the display mode value. The display mode determines what information, if any, is shown on the second line of the Model 715 display.**

Action: **DM** sets the second line of Model 715 display to the desired mode. Refer to Table 5-11 for the available display modes and associated **DM** values.
Range: 0 - 10
Default: 0
Typ. Set Command: *0100EW*0100DM=6
Typ. Set Response: *0001DM=6
Typ. Read Command: *0100DM
Typ. Read Response: *0001DM=1

TABLE 5-11: DM Command Options

DM Value	Display Mode
0	Horizontal bar graph indicating measured pressure as a percentage of full-scale pressure.
1	Internal transducer temperature
2	User-defined text defined by the UL parameter
3	No data is displayed on second line
4	User-defined text received with the DT command
5	Current tare value
9	Minimum pressure since last reset
10	Maximum pressure since last reset

DO **Set or read the display output port.**

Action: **DO** selects which serial port (RS-232 or RS-485) will produce data for the Model 715 display. The other serial port is normally used for communication with a host device, such as a PC.
Range: 0 or 1
Default: 0
Typ. Set Command: *0100EW*0100DO=1
Typ. Set Response: *0001DO=1
Typ. Read Command: *0100DO
Typ. Read Response: *0001DO=1

TABLE 5-12: DO Values

DO Value	RS-232 port	RS-485 port
0	Measurement data	715 Display data
1	715 Display data	Measurement data

NOTE: When **DO**=0, continuous pressure measurement data produced by **MD**=2, 3, 8, 10, 12, 14, or 15 is output on the RS-232 port. When **DO**=1, continuous pressure measurement data produced by **MD**=2, 3, 8, 10, 12, 14, or 15 is output on the RS-485 port.

DP **Set or read the maximum number of decimal places in the displayed pressure value.**

Action: **DP** sets the maximum number of decimal places in the displayed pressure value. Fewer decimal places will be displayed if the pressure resolution and/or pressure unit will not provide the specified number of decimal places. When **DP** is set to 6, the maximum number of decimal places is always displayed.
Range: 0 to 6
Default: 6
Typ. Set Command: *0100EW*0100DP=6
Typ. Set Response: *0001DP=6
Typ. Read Command: *0100DP
Typ. Read Response: *0001DP=6

DT **Set the text to be displayed on line 2 of the Model 715 display when DM=4.**

Action:	**DT** allows a serial host (such as a PC) to send text to be displayed on the bottom line. The text sent using **DT** is not stored by the Intelligent device, it is simply transferred to the Model 715 display. **DT** cannot be queried, and it is not necessary to precede **DT** with an **EW** command. The text is lost when the device or Model 715 is powered off.
Range:	16 characters maximum. Any characters in the range of ASCII 32 to ASCII 127 are legal.
Typ. Set Command:	*0100DT=This is my text
Typ. Set Response:	*0001DT=This is my text

PL **Read the overpressure indication set-point.**

This setpoint is used to determine the pressure at which the overpressure indication is displayed. **PL** is a factory-set, read-only command.

Action:	When the Intelligent device measures a pressure greater than the value of **PL**, an overpressure indication is displayed on the optional Model 715.
Typ. Read Command:	*0100PL
Typ. Read Response:	*0001PL=120.0000

NOTE: **PL** is factory-set typically to 1.2 times the overpressure limit as specified in the Specification Control Drawing for the device. **PL** is independent of **OP**; refer to page 51 on using the **OP** command.

UL **Set or read the text to be displayed on the second line when the Stored Text display option (DM=2) is selected.**

Action:	**UL** defines the text to be displayed on line 2 of an optional Model 715 display when **DM**=2. The value of **UL** is stored in non-volatile memory, and will therefore be retained even if power is lost. The value of UL is sent to the optional Model 715 display each time the pressure data is updated.
Range:	11 characters maximum. Any characters in the range of ASCII 32 to ASCII 127 are legal.
Default:	11 space characters
Typ. Set Command:	*0100EW*0100UL=My label
Typ. Set Response:	*0001UL=My label
Typ. Read Command:	*0100UL
Typ. Read Response:	*0001UL=My label

CAUTION

Do not use **UL** if it is necessary to update the displayed text often; use the External Text display option and the **DT** command instead. The nonvolatile memory used to store the text data can be written approximately 100,000 times; excessive use of **UL** will eventually result in the inability to change its value.

5.16 Time Reference Stamp Command

NOTE: Time reference stamp feature is available in firmware version 4.10 or later.

A time reference stamp can be appended to pressure and temperature measurement data to help you determine when the pressure or period measurement was taken, relative to the transmission of the measurement command response. The time reference value reported is the time interval between the midpoint of the integration period and the start of the transmission of the first ASCII character of the response data.

TS **Enables and disables the time reference stamp feature.**

The TS command affects the following measurement commands: **P1**, **P2**, **P3**, **P4**, **P5**, **P6**, **P7**, **Q1**, **Q2**, **Q3**, **Q4**, **Q5**, and **Q6**.

Action:	When enabled, a comma delimited time reference stamp is appended to the measurement values returned by the aforementioned commands, expressed in microseconds.
Range:	0 = Time reference stamp disabled 1 = Time reference stamp enabled
Typ. Set Command:	*0100EW*0100TS=1
Typ. Set Response:	*0001TS=1
Typ. Read Command:	*0100TS
Typ. Read Response:	*0001TS=1

The time reference value reported is the time interval between the midpoint of the integration period and the start of the transmission of the first ASCII character of the response data, expressed in microseconds. **DL**=1 pads the time reference stamp value to 9 digits.

NOTE: The time reference stamp feature is not compatible with fetch mode. If **FM**=1 (fetch mode active), >ERR:S1 is returned instead of the time reference stamp value.

Examples:
(Pressure = 14.74638, time reference stamp = 500637 microseconds)
P3 response, **DL**=0: *000114.74638,500637
P3 response, **DL**=1: *0001+14.746380000,000500637

Transmission Delay - The response data as seen by the serial host is delayed by the time it takes to transmit the data. For high accuracy applications, it is necessary to compensate for this delay. The formula for calculating transmission delay time is as follows:

$T = (N * 10) (1E6/BR)$

Where: T = transmission delay in microseconds
N = number of characters transmitted
BR = baud rate

Don't forget to consider the carriage return and line feed characters when determining the number of characters transmitted.

Processing Delay - For high accuracy applications, it is also necessary to compensate for any delay by the serial host in acknowledging the first character of the response data.

5.17 Calibration Commands

The calibration commands set and read several parameters that directly affect the measurement accuracy of the device. Refer to Sections 7.3, 7.4, and 13 for more information regarding the use of the calibration parameters.

⚠ CAUTION

Calibration values should be modified only when absolutely necessary, and then with extreme caution. Calibration value adjustments should only be performed by a qualified metrology lab. Calibration coefficients are unique to each product and should never be modified or transferred to another unit.

ZERO AND SPAN ADJUSTMENT COMMANDS

The **PA** command is used to make zero offset adjustments to the indicated pressure value. The **PM** command is used to make span adjustments to the indicated pressure value.

PA and **PM** are used in the following formula to calculate final output pressure:

$P_{adjusted} = PM * (P + PA)$

Where: P = Pressure calculated using original calibration coefficients in the current pressure unit.
PM = the current value of the **PM** parameter.
PA = the current value of the **PA** parameter

PA **Set or read the pressure adder parameter.**

Action:	The pressure adder parameter is used to make zero adjustments to the calibration. **PA** can also be used to offset absolute pressure measurements by atmospheric pressure to obtain gauge pressure.
Range:	-9999999 to 9999999
Default:	0.0
Typ. Set Command:	*0100EW*0100PA=.0000123
Typ. Set Response:	*0001PA=.0000123
Typ. Read Command:	*0100PA
Typ. Read Response:	*0001PA=.0000123

NOTE: The value of **PA** is entered in the current pressure units, but is converted to psi prior to being stored. When **PA** is queried, it returns the value scaled to the current pressure units.

PM **Set or read the pressure multiplier parameter.**

Action:	The pressure multiplier parameter is used to make span adjustments to the calibration.
Range:	-9999999 to 9999999
Default:	1
Typ. Set Command:	*0100EW*0100PM=1.000123
Typ. Set Response:	*0001PM=1.000123
Typ. Read Command:	*0100PM
Typ. Read Response:	*0001PM=1.000123

NOTE: The value of **PM** is dimensionless, and is therefore not scaled if the units are changed.

CALIBRATION COEFFICIENT COMMANDS

These commands contain the calibration coefficients for the Digiquartz pressure device.

C1, C2, C3, D1, D2, T1, T2, T3, T4, T5, U0, Y1, Y2, Y3

Set or read the calibration coefficients.

Default:	Device-specific
Typ. Set Command:	*0100EW*0100C1=228.1234
Typ. Set Response:	*0001C1=228.1234
Typ. Read Command:	*0100C1
Typ. Read Response:	*0001C1=228.1234

Refer to Section 13, page 99 for more information on calibration.

TIMEBASE CALIBRATION COMMANDS

TC is used to normalize the nominal 14.7456 MHz reference crystal frequency to 10 MHz to compensate for the natural variation in reference crystal frequency.

TC **Read the factory-set crystal timebase correction factor.**

Action:	Read the **TC** value. **TC** is a read-only command.
Typ. Read Command:	*0100TC
Typ. Read Response:	*0001TC=.6666667

5.18 Global Commands

Under certain circumstances, it may be necessary to send a single command to multiple Intelligent devices on a serial loop or multi-drop network. The ID 99 has been reserved for such global addressing. When an Intelligent device receives a supported command addressed to ID 99, the device reacts to that command regardless of its assigned ID value.

To support the unique requirements of RS-232 serial loop and RS-485 multi-drop networking, Intelligent devices react to global commands differently depending on which port received the command. When a global command is received via RS-232, the global command is re-transmitted before acting on the command. This ensures that all devices on a serial loop will receive the global command. When a global command is received via RS-485, the Intelligent device acts on the command but does not send a response. This prevents multiple devices on a multi-drop network from transmitting simultaneously, which would result in data collisions and unintelligible data.

SUPPORTED GLOBAL COMMANDS

All commands that affect serial communication must be globally addressed:

BR, **BL**, and **ID**.

Global addressing is often used with sample and hold measurement commands to synchronize measurements from multiple devices. The sample and hold measurement commands are:

P5, **P6, Q5**, and **Q6**

Most sampling commands and certain other commands may be either individually or globally addressed:

E1 through **E6, P1** through **P7, Q1** through **Q6, TT (A1), RH (A2), DB, DS, VR,** and **EW**

The remaining commands should not be sent as global commands.

NOTE: **DS** is available with firmware version R3.00 and later.

CAUTION

Global sampling commands sent to multiple units on an RS-485 multi-drop network may result in data collisions when multiple devices respond simultaneously.

6 Nano-Resolution Features & Functions

6.1 Introduction

Nano-Resolution is a new measurement mode capable of part-per-billion resolution and is available in firmware versions R5.10 and later. It is enabled by a serial command, and can be used with all measurements commands.

Nano-Resolution has significantly higher processing requirements, and therefore consumes more power. Consult the SCD for your product for details regarding power consumption.

In general, the nano-resolution feature is only useful if pressure is stable enough over effective sampling period and the data acquisition system can handle additional digits. The practical bandwidth of interest is in the infrasound and deep infrasound (10 to 0.001 Hz).

6.2 Technical Information

Nano-resolution is achieved by sub-sampling the pressure at a high rate (typically 8 kHz) and applying digital signal processing via an infinite impulse response (IIR) filter. It consists of a 5-stage digital low-pass filter acting on the sub-samples. It filters all frequencies with a -100 dB/decade roll-off above a user selectable cutoff frequency. It is an effective anti-aliasing filter. The inherent resolution depends on the cutoff frequency and not on the sampling period. Typically the sampling rate is set at the Nyquist limit, or twice the cutoff frequency.

6.3 Resolution and Data Rate

Unlike standard resolution mode, data rate and resolution are completely independent in nano-resolution mode and are selected using separate commands. It is recommended that resolution is selected first. Data rate is then selected based on the resolution setting. A data rate of approximately twice the cutoff frequency is generally recommended to avoid aliasing.

6.3.1 Enable and Set Nano-Resolution

Nano-resolution can be enabled and disabled by the **XM** serial command. Resolution is a function of the cutoff frequency when nano-resolution is enabled. The cutoff frequency is set by the **IA** command.

XM **Set or read the resolution mode.**

Range:	0 = Standard Resolution 1 = Nano-resolution (**OI** resets to 0 when **XM**=1)
Default:	0
Typ. Set Command:	*0100EW*0100XM=1
Typ. Set Response:	*0001XM=1
Typ. Read Command:	*0100XM
Typ. Read Response:	*0001XM=1

IA **Set or read the cutoff frequency setting.**

Range:	3 - 14
Default:	11
Typ. Set Command:	*0100EW*0100IA=11
Typ. Set Response:	*0001IA=11
Typ. Read Command:	*0100IA
Typ. Read Response:	*0001IA=11

Refer to Table 6-1 for a list of options for **IA** values, filter delay, cutoff frequencies, measurement resolution, and the number of digits reported.

6.3.2 Setting Data Rate

The method for controlling data rate in nano-resolution mode differs depending on whether continuous measurements (**P4**, **P2**, etc.) or polled measurements (**P3**, **P1**, etc.) are being taken. Continuous measurements are usually recommended since it is much simpler to control data rate.

Continuous Commands - Timing of continuous measurements in nano-resolution mode is determined by **TH** or **PI**. **TH** specifies the measurement rate in Hz, and is the preferred method. **PI** sets the approximate measurement interval in milliseconds, and is in effect when **TH**=0.

Polled Commands - The concept of integration time does not apply in nano-resolution mode, and as a result, polled commands such as **P3** return a measurement value immediately, regardless of **TH** and **PI** settings. Measurement timing must be controlled by the serial host that issues the measurement commands. Continuous measurement commands are recommended instead whenever consistent measurement timing is desired.

NOTE: See Section 6.4 for instructions on using the **TH** command.

To avoid aliasing, it is generally recommended to select a data rate that is approximately twice the cutoff frequency. Refer to Table 6-1 for cutoff frequencies associated with each **IA** setting.

Example:
If **IA** = 7 and the cutoff frequency is 3.8 Hz, then the recommended data rate is approximately 8 Hz.

6.4 IIR Filter Options for Nano-Resolution

TABLE 6-1: IIR Filter Typical Settings

IA	Filter Delay[a]	Cutoff Frequency[b]	Minimum Measurement Rate[c]	Period Resolution[d]	Measurand Resolution[e]		Pressure/ Temperature Digits[f]
	(sec)	(Hz)	(Hz)	(dB)	(dB)	(ppm/ppb)	
3	0.0048	65	130	-117	-97	14 ppm	8
4	0.0097	30	60	-127	-107	4.5 ppm	8
5	0.019	15	30	-140	-120	1.0 ppm	8
6	0.039	7.5	15	-149	-129	0.35 ppm	9
7	0.077	3.8	7.5	-157	-137	0.14 ppm	9
8	0.15	1.9	3.8	-167	-147	45 ppb	10
9	0.31	1.0	2.0	-177	-157	14 ppb	10
10	0.62	0.50	1.0	-186	-167	4.5 ppb	11
11	1.24	0.25	0.50	-196	-176	1.6 ppb	11
12	2.47	0.12	0.25	-203	-183	0.7 ppb	12
13	4.95	0.06	0.12	-206	-186	0.5 ppb	12
14	9.90	0.03	0.06	-207	-187	0.4 ppb	12

a. *Filter Delay* is a time constant associated with each value of **IA** that describes the time needed for a pressure event to propagate through the IIR filter. Allow five time constants for a pressure event to propagate fully through the IIR filter.
b. *Cutoff Frequency* is the -3dB point of the low-pass IIR filter.
c. *Minimum Measurement Rate (MMR)* is the recommended minimum sampling rate to avoid aliasing. The measurement rate is set using the **TH** command (R5.20 and later) or the **PI** command (versions prior to R5.20). Values for MMR are approximately twice that of Cutoff Frequency.
d. *Period Resolution* is the resolution of pressure and temperature period measurements.
e. *Measurand Resolution* is the resolution of pressure and temperature measurements.
f. *Pressure and Temperature Digits* is total number of digits used to report pressure and temperature measurements. Pressure and temperature period measurements contain one additional digit.

6.5 Nano-Resolution Application Example

This example gives the steps required to configure an intelligent device for nano-resolution pressure measurements, according to the requirements of a particular application.

STEP 1: Enable Nano-Resolution mode

- Issue the command **0100EW*0100XM=1* to enable nano-resolution mode.

STEP 2: Determine the frequency range of interest

- For this example, let us assume the measured pressure data will contain information of interest at 4 Hz and below.

STEP 3: Set the IIR filter cutoff frequency

- Since the pressure information of interest is expected to be at or below 4 Hz, the cutoff frequency should be set at or near this value. Referring to Table 6-1, an **IA** value of 7 specifies an IIR cutoff frequency of 3.8 Hz.
- Issue the command **0100EW*0100IA=7* to set the IIR cutoff frequency to 3.8 Hz.

STEP 4: Set the measurement rate at or above the Nyquist rate

- The Nyquist rate is twice the IIR filter cutoff frequency. Sampling below the Nyquist rate can introduce aliasing and produce erroneous results. Since we have specified an IIR cutoff frequency of 3.8 Hz, the Nyquist rate is two times 3.8 Hz, or 7.6 Hz. The measurement rate should therefore be at least approximately 8 Hz to avoid aliasing.
- For this example, 10Hz is a convenient measurement rate that is close enough to the Nyquist rate of 8 Hz. It is possible to issue individual pressure measurement commands at 10 Hz but that is often impractical. The preferred method is to use a continuous measurement command with its measurement rate set by the **TH** command.
- Issue the command **0100EW*0100TH=10,P4* to set the measurement rate to 10 Hz.

NOTE: The **TH** command is available in firmware version R5.20 and above. In earlier firmware versions, **PI** can instead be set to a value of approximately 100 to produce measurements at a rate of approximately 10 Hz.

STEP 5: Begin taking pressure measurements

- Issue the command **0100P4* to begin acquiring continuous pressure measurements at the rate set by the **TH** command. Other continuous pressure measurement commands may also be used instead of **P4**.

6.6 Numeric Format For Nano-Resolution

6.6.1 Default Format

The default numeric formats used to report period, pressure, and temperature measurement values are as follows, where N = the number of significant digits shown in the resolution tables.

Pressure - The sensor full-scale pressure defines the number of digits reserved for the integer portion of the pressure value. For example, a 1000 psi full-scale unit would have 4 digits reserved (but not necessarily used) for the integer portion of the pressure value, leaving N-4 digits for the fractional portion.

Temperature - Three digits are reserved (but not necessarily used) for the integer portion of the temperature value, leaving N-3 digits for the fractional portion. Negative temperature values include a sign but the numeric format is otherwise unaffected.

Pressure Period - Two digits are used for the integer portion of the pressure period value, leaving N-2 digits for the fractional portion.

Temperature Period - One digit is used for the integer portion of the pressure period value, leaving N-1 digits for the fractional portion.

6.6.2 Controlling the Numeric Format

The **XN** command sets the number of significant digits used to report period, pressure, and temperature measurement values. The **XN** command overrides the default numeric format.

XN **Set or read the number of significant digits.**

Range:	0 - 13
Default:	0
Typ. Set Command:	*0100EW*0100XN=10
Typ. Set Response:	*0001XN=10
Typ. Read Command:	*0100XN
Typ. Read Response:	*0001XN=10

When **XN**=0, the default numeric formats are used. When non-zero, **XN** specifies the number of significant digits used to report period, pressure, and temperature measurement values.

The integer portion of the measurement value is never altered regardless of the value of **XN**. Only the fractional portion of the measurement value is rounded as required to conform to the format specified by **XN**.

The number of digits in the integer portion of the full-scale pressure (**PF**) is used to determine the number of digits reserved but not necessarily used for the integer portion of pressure values.

Example:
If the full-scale pressure is 1000 psi, four digits are reserved for the integer portion, leaving **XN** minus 4 digits available for the fractional portion. If the pressure value is 14.12345678 and **XN**=8, the value would be formatted as 14.1235. Four digits were reserved for the integer portion but only two were needed, leaving 4 digits available for the fractional portion.

The **XN** command works in both standard resolution and nano-resolution modes.

Refer to Table 6-2 for examples of formatted measurement values for **XN**. The examples assume a transducer full-scale pressure (**PF**) of 16 psi.

TABLE 6-2: Examples of Formatted Measurement Value Using XN

XN	Measurement Value	Formatted Measurement Value
0	14.12345678901	14.12345678901
1	14.12345678901	14
2	14.12345678901	14
3	14.12345678901	14.1
4	14.12345678901	14.12
5	14.12345678901	14.123
6	14.12345678901	14.1235
7	14.12345678901	14.12346
8	14.12345678901	14.123457
9	14.12345678901	14.1234568
10	14.12345678901	14.12345679
11	14.12345678901	14.123456789
12	14.12345678901	14.1234567890
13	14.12345678901	14.12345678901

7 Pressure Measurement Concepts

7.1 Resolution, Integration Time, and Sampling Rate

NOTE: This section applies to standard resolution mode only.

The outputs from Digiquartz pressure transducers are two square wave signals whose period is proportional to applied pressure and internal transducer temperature. The Intelligent electronics measures these signals using a technique similar to that of a common laboratory frequency counter. Like the frequency counter, a signal must be integrated for a specified time to measure its period.

The time over which the signal is integrated determines the resolution of the measurement. Longer integration times increase resolution, but reduce the sampling rate. Conversely, shorter integration times decrease resolution, but increase the sampling rate.

The integration mode has a significant effect on sampling rate. The effective sampling rate of Simultaneous Integration (**OI**=0) is roughly double that of Sequential Integration Simulation (**OI**=1) for a given **PI** or **PR** setting, until the maximum serial bandwidth is reached. Note that the relationship between integration time and pressure resolution is not affected by the integration mode. Please refer to Section 2.3, page 14 and Section 5.7, page 43 for more information about Sequential Integration and Simultaneous Integration Simulation.

Another factor that influences sampling rate is the serial baud rate. For short integration times, faster baud rates enable faster sampling. As integration times increase, the benefit of faster baud rates quickly diminishes.

Table 7-1 on the following page illustrates the relationship between integration time, resolution, and sampling rate for the **P4** command in Simultaneous Integration and Sequential Integration Simulation modes at various baud rates.

P4 COMMAND (CONTINUOUS PRESSURE OUTPUT)

TABLE 7-1: Relationship of Integration Time, Resolution, and Sampling Rate for P4

PI[a]	Resolution (ppm)		Integration Time (sec)		Sampling Rate (Hz)[b,c] 9600 Baud		57600/115200 Baud	
	OI=0	OI=1	OI=0	OI=1	OI=0	OI=1	OI=0	OI=1
1	678.200	339.100	0.001	0.002	106.70	106.70	418.00	300.00
3	226.100	113.000	0.003	0.006	106.70	106.70	232.00	134.00
8	84.770	42.390	0.008	0.016	87.30	57.00	106.00	57.00
11	61.650	30.830	0.011	0.022	80.00	42.00	80.00	42.00
17	39.890	19.950	0.017	0.034	54.00	28.00	54.00	28.00
34	19.950	9.970	0.034	0.068	28.00	14.40	28.00	14.40
67	10.120	5.061	0.067	0.134	14.60	7.37	14.60	7.37
134	5.061	2.530	0.134	0.268	7.38	3.71	7.38	3.71
333	2.037	1.018	0.333	0.666	2.99	1.50	2.99	1.50
666	1.018	0.509	0.666	1.332	1.50	0.75	1.50	0.75
1333	0.509	0.254	1.333	2.666	0.75	0.38	0.75	0.38
3332	0.204	0.102	3.332	6.664	0.30	0.15	0.30	0.15
6664	0.102	0.051	6.664	13.328	0.15	0.08	0.15	0.08
13328	0.051	0.025	13.328	26.656	0.08	0.04	0.08	0.04
26656	0.025	0.013	26.656	53.312	0.04	0.02	0.04	0.02
45872	0.015	0.007	45.872	91.744	0.02	0.01	0.02	0.01

a. Data in this table assumes **TI** = **PI**. **PR** is approximately equal to **PI** x 2.8.
b. The measurement time interval (seconds) is equal to 1 / Sampling Rate (Hz).
c. Data rates are approximations only and may vary slightly for different firmware versions.

NOTE: Refer to Section 2.3, page 14 and Section 5.7, page 43 for more information about Simultaneous Integration and Sequential Integration Simulation.

7.2 High-Speed Sampling

Use one or more of the techniques shown in Table 7-2 to increase sampling rate:

TABLE 7-2: SAMPLING RATE TECHNIQUES

To try one of the following actions:	Use Command	On Page:
Select Simultaneous Integration	**OI**	43
Turn off any data being sent to Model 715 display	**MD**	45
Increase baud rate	**BR**	27
Reduce integration time	**PI**, **TI**	36
Use a continuous pressure measurement command, such as **P4**.	**P4**	30
Use the continuous pressure period command, and post-process data to convert to pressure	**P2**	71
Turn off the time reference stamp function	**TS**	59

7.3 Calculations and Formulas

Internal sensor temperature and applied pressure are calculated from period measurements of the two transducer output signals. The equations and coefficients used to perform these calculations are described below. Refer to the Calibration Coefficient Sheet for the actual coefficient values for your transducer.

7.3.1 Temperature Calculation

The following equation is used to calculate internal sensor temperature:

$$T = Y_1U + Y_2U^2 + Y_3U^3$$

Where: T = Temperature (°C)
U_0 = temperature signal period (microseconds) at 25° C
U = temperature signal period (microseconds) – U_0 (microseconds)
Temperature coefficients: U_0 Y_1 Y_2 Y_3

7.3.2 Pressure Calculation

The following equation is used to calculate pressure:

$$P = C(1 - T_0^2/Tau^2)[1 - D(1 - T_0^2/Tau^2)]$$

Where: P = pressure
Tau = pressure signal period (microseconds)
U = temperature signal period (microseconds) – U_0 (microseconds)
$C = C_1 + C_2U + C_3U^2$
$D = D_1 + D_2U$
$T_0 = T_1 + T_2U + T_3U^2 + T_4U^3 + T_5U^4$
Pressure Coefficients: C_1 C_2 C_3 D_1 D_2 T_1 T_2 T_3 T_4 T_5

7.3.3 Final Output Pressure Calculation

The following equation is used with the pressure value calculated above to calculate the final output pressure value:

$$P_{output} = \mathbf{PM}[(\text{units multiplier}) \times P + \mathbf{PA}]$$

Where: P_{output} = Final output pressure value (psi)
P = raw pressure value (from pressure equation above)
PM = Value stored in the **PM** parameter
PA = Value stored in the **PA** parameter
Units multiplier =Value used to convert psi to the current pressure unit.

The **PM** and **PA** parameters allow you to make minor zero and span adjustments to the raw pressure value. Normally, **PM** (pressure multiplier) is set to 1.0, and **PA** (pressure adder) is set to 0.0. Refer to Sections 5.17 on page 60 and 7.4 below for more information.

7.4 Zero and Span Adjustments

The **PM** and **PA** commands allow for minor zero and span adjustments to the raw pressure value. Normally, **PM** (pressure multiplier) is set to 1.0, and **PA** (pressure adder) is set to 0.0.

Adjusted pressure is calculated using the following equation:

$$P_{adjusted} = \mathbf{PM} \times (P + \mathbf{PA})$$

Where: P = Pressure calculated using original calibration coefficients, in the current pressure units
PM = the current value of PM
PA = the current value of PA

Refer to Sections 5.17 on page 60 and 7.3.3 for more information regarding **PA** and **PM**.

⚠ CAUTION

Use extreme caution when modifying **PA** or **PM** because they directly affect calibration. Inaccurate values will result in inaccurate pressure measurements.

8 Networking Multiple Intelligent Devices

Digiquartz Intelligent devices support RS-232 serial loop and RS-485 multi-drop networking. Networking allows you to communicate with up to 98 Digiquartz Intelligent devices from a single RS-232 or RS-485 serial host.

8.1 Networking Basics

WHEN SETTING UP A NETWORK, THE FOLLOWING MUST BE OBSERVED:

- Verify proper operation of each Digiquartz Intelligent device before installing it in a network.
- If your network includes older Digiquartz Intelligent devices using SX.XX series firmware, set the older devices to **PT** = N to assure compatibility with the newer devices.
- Set all Digiquartz Intelligent devices to the same baud rate before installing them in a network. Once your network is up and running, you can change the baud rate to any supported value.
- Each Digiquartz Intelligent device on the network requires a unique Unit ID.
  - If you are setting up an RS-232 serial loop network, you can automatically set all devices to a unique ID value by issuing a single **ID** command.
  - If you are setting up an RS-485 multi-drop network, you must isolate each device from the network, and set the ID of each device individually.
  - See page 28 for more information on using the **ID** command.

8.2 Choosing a Network Type

RS-232 and RS-485 networks have unique benefits, as described below. Carefully consider your system requirements before selecting a network type.

BENEFITS OF RS-485 MULTI-DROP NETWORKS:

- RS-485 transmission distance is up to 4,000 feet, compared to 50 feet for RS-232 serial loop networking.
- Improved data integrity in electrically noisy environments, as compared to RS-232 serial loop networks.
- Can take synchronized measurements from any or all devices on the network. This is not possible with RS-232 serial loop network due to the delays that occur as the measurement command propagates through the network.
- Can wake up all sleeping devices with a single character. Each device must be awakened individually on an RS-232 serial loop network.
- Improved system reliability. It is less likely that a failure in a single unit will affect the entire network, as compared to RS-232 serial loop networks.

BENEFITS OF RS-232 SERIAL LOOP NETWORKS:

- RS-232 serial loop networks are compatible with most standard PCs, and most other control devices. RS-485 may not be available or may require additional hardware, depending on the serial host you have selected.
- Unique device IDs can be assigned to all devices on the network with a single command. With an RS-485 multi-drop network, you must isolate each unit and assign its unique ID individually.
- Can directly communicate with up to 98 devices. You can address up to 98 devices with RS-485, but you must use a repeater if you have more than 32 devices (including the host) on the network.

8.3 RS-485 Multi-drop Networks

As described in Section 8.2, page 73, RS-485 multi-drop offers several significant benefits over RS-232 serial loop networking. It is recommended that RS-485 multi-drop networks be used whenever possible.

RS-485 multi-drop networks can be wired as a 2-wire or 4-wire system. Digiquartz Intelligent devices are compatible with either system. Refer to Section 11.2.4, page 94 for multi-drop network wiring diagrams.

RS-485 MULTI-DROP NETWORK CONSIDERATIONS

When setting up and operating an RS-485 multi-drop network, please be aware that up to 98 devices can be addressed on an RS-485 multi-drop network, but a maximum of 31 devices can be driven by any single transmitter. If you intend to build a network that exceeds 31 Digiquartz Intelligent devices, you must use one or more RS-485 repeaters to ensure that no device is driving more than a maximum of 31 receivers.

⚠ CAUTION

Do not attempt to set Unit ID values over a multi-drop network. Doing so will set all devices on the network to the same Unit ID value. To set each device to a unique Unit ID, isolate each device from the network, and individually set its Unit ID value.

⚠ CAUTION

Do not send continuous measurement commands (**P2**, **P4**, **P7**, **Q2**, **Q4**) to any device on a 2-wire multi-drop network. If you do this, you may need to cycle power to stop the continuous transmission of measurement data, since the command from the host to stop continuous measurement will likely collide with the measurement data coming from the device. This is especially true if your device is set for a short integration time.

CAUTION

Do not configure any device on a 2 -wire RS-485 network for continuous pressure data output from the RS-485 port on power-up (**MD**=2 or **MD**=3, **DO**=1). If you do this, it is unlikely that you will be able to reconfigure the unit over the network, since any command is likely to collide with the pressure data being continuously sent. To recover, you will need to remove the device from the network and reconfigure it individually via the RS-232 port.

2-WIRE RS-485 MULTI-DROP NETWORKS

Digiquartz Intelligent devices support half-duplex, master-slave communications with serial hosts. This means that the device (slave) will only transmit if it has been commanded to do so by the serial host, or master. This feature enables the Intelligent devices to be used in 2-wire RS-485 systems, where commands sent from the host and responses sent by the Intelligent devices are sent on the same pair of wires.

Figure 11-18 on page 94 illustrates a two-wire RS-485 multi-drop network consisting of a host and multiple Digiquartz Intelligent devices. Notice that the TX+ and RX+ signals and the TX- and RX- signals are tied together at each device, forming a 2-wire interface. The 2-wire half duplex configuration can reduce wiring costs, but the system designer must take precautions as described above to ensure reliable communications.

Data collisions occur on 2-wire RS-485 systems when two or more slaves transmit simultaneously, or when the master and one or more slaves transmit simultaneously. The result of a data collision is that both transmissions become unintelligible and are lost. In a master-slave network, it is the responsibility of the serial host to ensure that data collisions do not occur. Normally, this requires that the host wait an appropriate length of time for a response before sending another command.

Since multiple transmitters share common wiring in 2-wire RS-485 multi-drop systems, it is necessary that all devices on a network have the ability to disable their transmitters when not actively transmitting. Digiquartz Intelligent devices perform this task automatically, but the serial host must also enable its transmitter only when transmitting. Some RS-485 devices, particularly low-cost RS-232 to RS-485 converters, tend to leave their transmitters enabled for a period of time after RS-485 data has been transmitted. If this time is sufficiently long, some or all of the response data from a Digiquartz Intelligent device will not be received by the serial host, since the host will still be in the transmit mode when the response is being sent. If you plan to use such a device, reliable two-wire RS-485 communications may not be possible, and you will need to use a 4-wire system instead.

4-WIRE RS-485 MULTI-DROP NETWORKS

Figure 11-19 on page 94 illustrates a 4-wire RS-485 multi-drop network consisting of a host and three Digiquartz Intelligent devices. In this system, there is no need for the host to disable its transmitter, since it is connected to the receive lines of the Intelligent devices via a dedicated pair of wires, enabling full-duplex operation.

8.4 RS-232 Serial Loop Networks

In an RS-232 serial loop network, the transmit output of the RS-232 host is connected to the receive input of the first device in the loop (see Figure 8-1). The transmit output of the first device is connected to the receive input of the next device. The remaining devices are connected similarly, with their receive input connected to the transmit output of the previous device, and their transmit output connected to the receive input of the next device. The transmit output of the last device is connected to the receive input of the RS-232 host.

The host sends commands to the first device in the loop. If a command is addressed to that device, the command is carried out; if not, the command is resent to the next device. Globally addressed commands are carried out by each device, and are also resent to the next device. When a device responds to a command, the response is addressed to the host, and is therefore resent by each device that receives it until it eventually makes it way to the serial host.

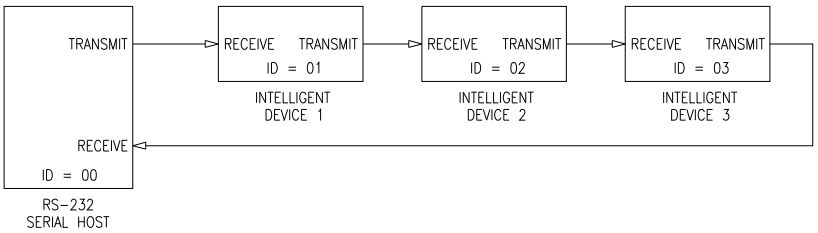

FIGURE 8-1: Serial Loop Network Block Diagram

Keep these points in mind when designing an RS-232 serial loop network:

- As previously described, each device will resend any command or response that is addressed to another device. Since each device considers resending to be a higher priority than sending its own response, it is possible that a device can spend all its time resending, and never have an opportunity to send its own response. This occurs only when one or more upstream devices are continuously transmitting. To prevent this situation:
  - Operate your network at 9,600 or 19,200 baud.
  - Avoid continuous transmission (**P2**, **P4**, **P7**, **Q2**, and **Q4** commands) at extremely low integration times.
- Do not operate a serial loop network above 19,200 baud.
- A single **ID** command will automatically set all devices on the serial loop to unique sequential IDs.
- It is not possible to precisely synchronize measurements from two or more devices by sending a global measurement command. This is a result of the delay that occurs as the measurement command propagates through the serial loop. If precise measurement synchronization is required, consider an RS-485 multi-drop network instead.

- When a global command is sent, it propagates through the serial loop, eventually making its way back to the host. Therefore, the data received by the host in response to a global command includes the command itself, followed by the individual responses from all devices on the network.
- Sleeping devices on a serial loop network must be awakened individually, and in sequence, by sending a complete command to each device, starting with the first device. Keep in mind that a serial loop network will not be fully operational unless all devices on the network are awake, since response data will not be resent by sleeping devices downstream.
- Digiquartz Interactive software (DQI3) is not capable of waking multiple sleeping devices on a serial loop network. If you intend to use DQI3 to communicate with units on a serial loop network, please ensure that all devices have the sleep mode disabled.

8.5 Other Networking Methods

MULTIPLE SERIAL PORTS

PC expansion boards are available which provide up to 32 individual RS-232 serial ports. Using such a board, it would be possible to design a system whereby each Intelligent device would be connected to the serial host via its own RS-232 port. This type of a system would ensure that any communications port, cable, or transmitter failure would not affect the rest of the system.

RELAY MULTIPLEXER SYSTEM

For high-reliability applications with a large number of transmitters, it may be desirable to use a custom relay multiplexer as a switching hub to select separate data lines running out to the individual transmitters or serial loops in the system. Loss of any one data line through accident or failure will affect only those transmitters on that data line.

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9 Using the Model 715 Display

The Model 715 is extremely simple and easy to use. There are no controls to set or configure, as the Digiquartz Intelligent device controls display information to the Model 715. Simply connect the display to an appropriately configured Digiquartz Intelligent device and a DC power source, and the Model 715 will display the desired information.

The Model 715 can communicate with a Digiquartz Intelligent device via either RS-232 or RS-485. You can therefore use either port to communicate with the Model 715. The Model 715 automatically sets its baud rate to match that of the Digiquartz Intelligent device.

The Model 715 provides a regulated 6.0 VDC output for powering a Digiquartz Intelligent device, eliminating the need to power the Intelligent device separately.

NOTE: The Model 715 Display is NOT compatible with RS-232 only devices.

9.1 Serial and Power Connections

DC power (7 – 25VDC, 270 mA max.) can be applied to a terminal block on the rear panel, or can be supplied by a 110VAC or 220 VAC wall power supply (part numbers 6377-001 or 6377-004).

Refer to Section 11.2.5, page 95 for Model 715 interconnection options.

9.2 Configuring Intelligent Device For Use With Model 715

Digiquartz Intelligent devices must be configured to be used with the Model 715 display. The following commands are available for this purpose:

MD	Enables output of display data. **MD** must be set to 1 or 3 for use with the Model 715 display. Refer to Section 5.9, page 45 for details.
DO	Selects either RS-232 or RS-485 communication with the Model 715. Set **DO** to 0 to communicate with the Model 715 display via the RS-485 port, or set **DO** to 1 to use the RS-232 port.
DM	Selects the type of information to be displayed on the second line of the Model 715 display.
DP	Selects the number of decimal points in displayed pressure measurements.

Refer to Section 5.15, page 56 for details on using the **DO**, **DM**, and **DP** commands.

NOTE: Do not set **PI** to a value of less that 10 when using a Model 715 display. Doing so may result in an inconsistent display. For reliable operation, do not use baud rates (**BR**) greater than 38,400 when using a Model 715 display.

9.3 Model 715 Panel Mounting Instructions

OVERVIEW

The Model 715 can be adapted for use in panel or rack-mounted applications. This section provides the necessary mounting information.

PANEL PREPARATION

Modify the mounting panel per Figure 9-1. All dimensions are in inches.

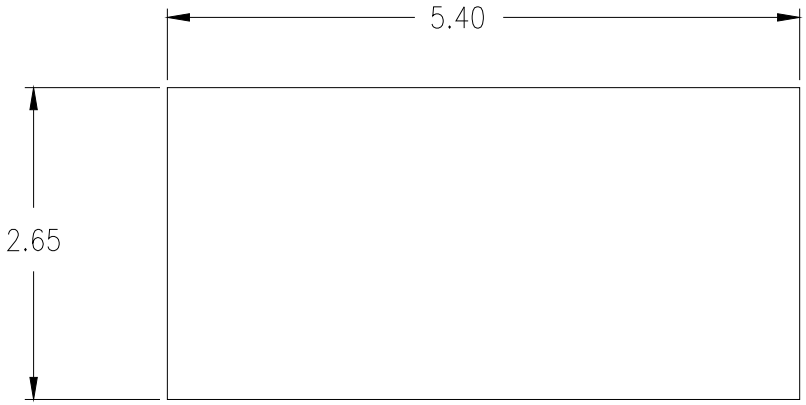

FIGURE 9-1: Model 715 Panel Cutout Detail

MOUNTING PROCEDURE

STEP 1: Remove Back Feet

Remove the rear rubber feet from the Model 715. The feet are glued to the Model 715 and can be reattached in the future if needed.

STEP 2: Remove Set Screws

Using a 1/16" hex key, remove the two setscrews on the rear panel as shown in Figure 9-2, then slide out the panel mount brackets from the sides of the Model 715.

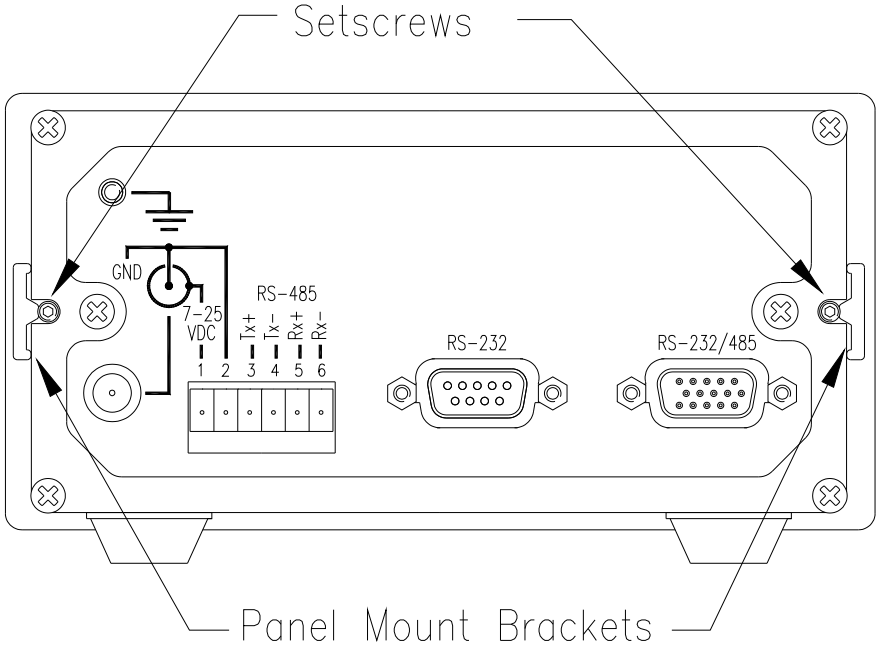

FIGURE 9-2: Model 715 Rear Panel Detail

STEP 3: Insert the Model 715 through the panel
Insert the back end of the Model 715 through the front of the panel cutout.

STEP 4: Replace the panel mount brackets
Slide the panel mount brackets into the slot on the side of the Model 715 and up against the panel.

STEP 5: Install setscrews
Insert the setscrews into the panel mount bracket and tighten.

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10 I/O Lines

Digiquartz Intelligent Transmitters feature discrete digital I/O lines that may be used to control and monitor tare and overpressure alarm functions. See Section 5.12, page 49 for more information regarding tare and overpressure functions.

NOTE: Some Digiquartz Intelligent Devices do not support the I/O lines described in this section. Refer to the SCD for the specific device in-use.

10.1 Input

TARE INPUT

Activated by a momentary contact closure to ground. When taring is not in effect and Tare Input is activated, taring is enabled on the next pressure measurement. When taring is in effect and Tare Input is activated, taring is disabled, and the next pressure measurement taken will not be tared.

WARNING

To prevent possible damage, do not connect any voltage source other than DC power ground to the Tare Input.

10.2 Output

TARE OUTPUT

Indicates whether the most recent pressure measurement was tared. The tare output is set to logic high when taring is in effect, is set to logic low when taring is not in effect.

OVERPRESSURE OUTPUT

Indicates whether the most recent pressure measurement exceeds the user-specified overpressure setpoint. The overpressure output is set to logic high if overpressure setpoint is exceeded, and is set to logic low otherwise. See the **OP** command on page 51 for more information.

- Logic low:< 0.1 VDC
- Logic high:3.3 VDC
- Maximum output drive current: 300µA (microamps)

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11 Connector and Wiring Diagrams

11.1 Connector Diagrams

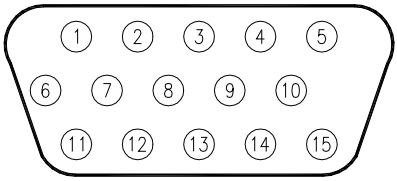
This section provides pin assignment diagrams for Digiquartz Intelligent devices and standard PCs. PC pin assignments are typical; if in doubt, consult the hardware manual that came with your PC.

NOTE: All connector diagrams are as viewed from the mating end of the device.

WARNING

Pinouts shown are based on standard product configurations. For custom configurations, consult the SCD for the specific electrical pinouts and voltage requirements.

11.1.1 Intelligent Device - RS-232/485



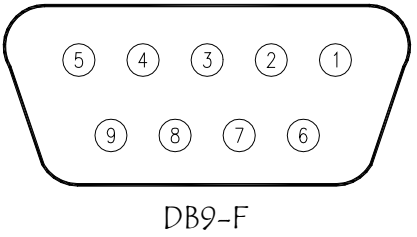
DB15M-HD

Pin	Connection
1	Chassis ground
2	RS-232 TX
3	RS-232 RX
4	Not used
5	Power/signal ground
6	Tare output
7	Tare switch input
8	Overpressure output
9	Power (consult SCD)
10	Not used
11	Not used / PPS Input[a]
12	RS-485 RX+
13	RS-485 RX-
14	RS-485 TX+
15	RS-485 TX-

a. Some configurations may have PPS input, see unit SCD for details.

FIGURE 11-1: Intelligent Transmitter - 15-Pin Connector Pinout

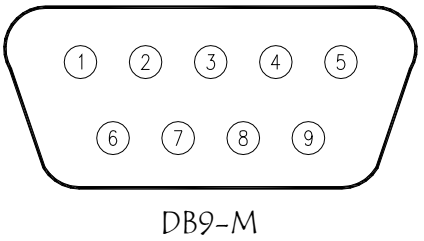
11.1.2 Intelligent Device - RS-232 Only



Pin	Connection
1	Chassis ground
2	RS-232 TX
3	RS-232 RX
4	not used
5	Power/Signal ground
6	not used[a]
7	not used
8	not used[b]
9	Power (consult SCD)

a. Display clock, Model 760 only.
b. Display data, Model 760 only.

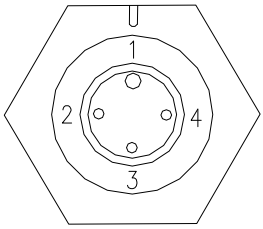
FIGURE 11-2: Model 1000 Intelligent Transmitter and Model 760 Portable Field Standard - 9-Pin Connector



Pin	Connection
1	not used
2	RS-232 TX
3	RS-232 RX
4	not used
5	Power/Signal ground
6	not used
7	Tare Output
8	not used
9	Power (consult SCD)

FIGURE 11-3: Model 6000 Intelligent Barometer, Model 9000 Intelligent Transmitter - 9-pin Connector

11.1.3 Depth Sensor - RS-232 Only



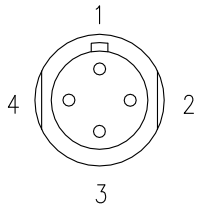
SEACON XSG-4-BCL

INTELLIGENT DEVICE	
Pin	Connection
1	RS-232 TX
2	RS-232 RX
3	Power/Signal ground
4	Power (consult SCD)

NON-INTELLIGENT DEVICE	
Pin	Connection
1	Temperature Signal[a]
2	Pressure Signal
3	Power/Signal ground
4	Power (consult SCD)

a. For non-temperature compensated units PIN 1 is not used.

FIGURE 11-4: 8B, 8DP, 8WD Depth Sensor - Seacon BCL Connector Pinout

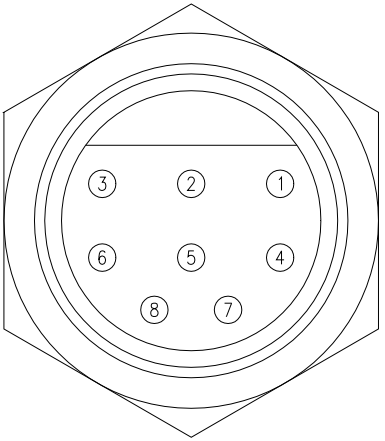


SEACON XSE-4-BCR

Pin	Connection
1	RS-232 TX
2	RS-232 RX
3	Power/Signal ground
4	Power (consult SCD)

FIGURE 11-5: 8DP Intelligent Depth Sensor - Seacon BCR Connector Pinout

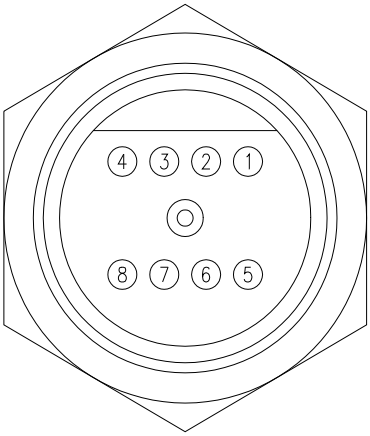
11.1.4 Intelligent Depth Sensor - RS-232/485



Pin	Connection
1	RS-232 TX
2	RS-232 RX
3	Power/signal ground
4	Power (consult SCD)
5	RS-485 RX+
6	RS-485 RX-
7	RS-485 TX+
8	RS-485 TX-

BURTON 5507-1508-00X

FIGURE 11-6: Intelligent Absolute Depth Sensor - Burton Connector Pinout

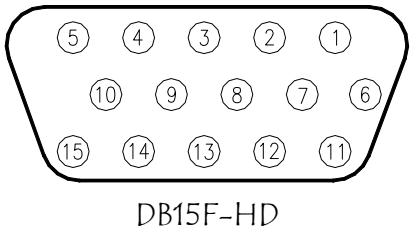


Pin	Connection
1	RS-232 TX
2	RS-232 RX
3	Power/signal ground
4	Power (consult SCD)
5	RS-485 RX+
6	RS-485 RX-
7	RS-485 TX+
8	RS-485 TX-

BURTON 5999-0962-002

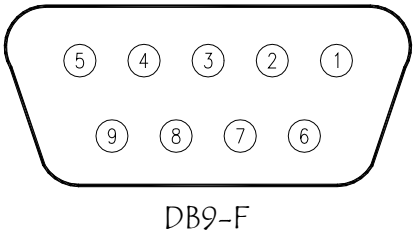
FIGURE 11-7: Intelligent Gauge Depth Sensor - Burton Connector Pinout

11.1.5 Model 715 Connector



Pin	Connection
1	Chassis ground
2	RS-232 TX
3	RS-232 RX
4	Not used
5	Power/signal ground
6	Tare output
7	Tare switch input
8	Overpressure output
9	Power (consult SCD)
10	Not used
11	Not used
12	RS-485 TX+
13	RS-485 TX-
14	RS-485 RX+
15	RS-485 RX-

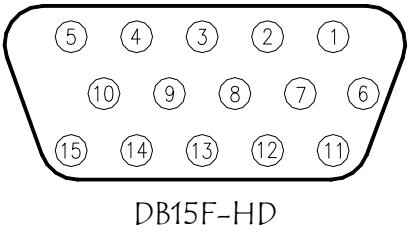
FIGURE 11-8: Model 715 -15-Pin Connector Pinout



Pin	Connection
1	Chassis ground
2	RS-232 TX
3	RS-232 RX
4	Not used
5	Signal ground
6	Not used
7	Not used
8	Not used
9	Not used

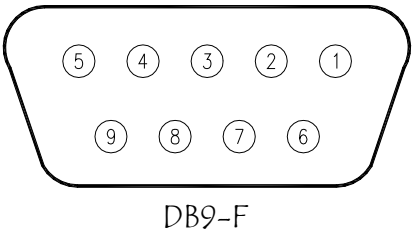
FIGURE 11-9: Model 715 - 9-Pin Connector Pinout

11.1.6 Power Adapter Module Connectors



Pin	Connection
1	Not used
2	RS-232 TX
3	RS-232 RX
4	Not used
5	Power / signal ground
6	Not used
7	Not used
8	Not used
9	Power (consult SCD)
10	Not used
11	Not used
12	RS-485 RX+
13	RS-485 RX-
14	RS-485 TX+
15	RS-485 TX-

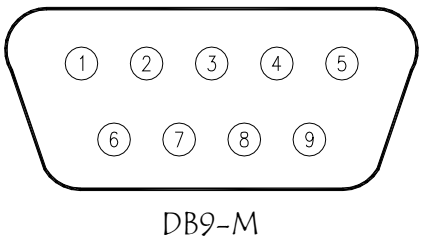
FIGURE 11-10: P/N 6671-003 Power Module - 15-Pin Connector Pinout



Pin	Connection
1	Not used
2	RS-232 TX
3	RS-232 RX
4	Not used
5	Power / signal ground
6	Not used
7	Not used
8	Not used
9	Power (consult SCD)

FIGURE 11-11: P/N 6671-003 Power Module - 9-Pin Connector Pinout

11.1.7 PC RS-232 Port: 9-pin Male D-Sub Connector



Pin	Connection
1	Data Carrier detect (DCD)
2	RS-232 RX
3	RS-232 TX
4	Data Terminal Ready (DTR)
5	Signal ground
6	Data Set Ready (DSR)
7	Request To Send (RTS)
8	Clear To Send (CTS)
9	Ring Indicator (RI)

FIGURE 11-12: Typical PC RS-232 - 9-Pin Connector Pinout

11.2 Serial Wiring Diagrams

The diagrams in this section show the various ways in which Digiquartz Intelligent devices can be connected to RS-232 and RS-485 serial hosts and the Model 715 display. The pin numbers given are for Digiquartz Intelligent devices with 15-pin high-density D-subminiature connectors. Refer to Section 11.1, page 85 for pin assignments of other connectors. PC serial port pin numbers assume a typical 9-pin RS-232 port; consult the documentation that came with your PC to verify your RS-232 port pin assignments.

11.2.1 RS-232 Wiring Diagrams

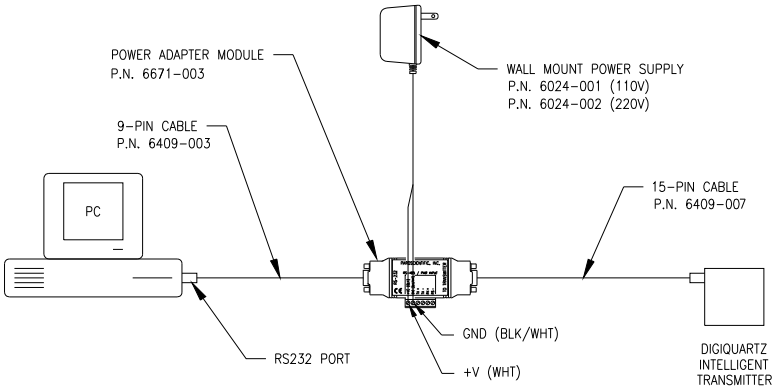


FIGURE 11-13: RS-232 Wiring Diagram Using Optional RS232/RS485 Power Module Kit

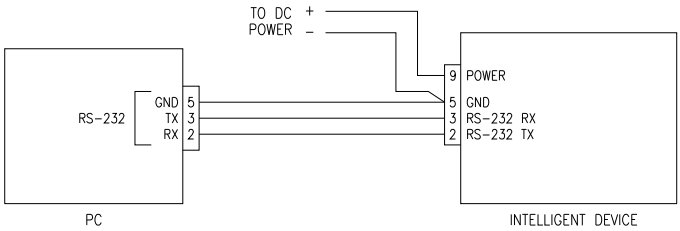


FIGURE 11-14: Simple RS-232 Wiring Diagram

11.2.2 RS-232 Serial Loop Network Wiring Diagram

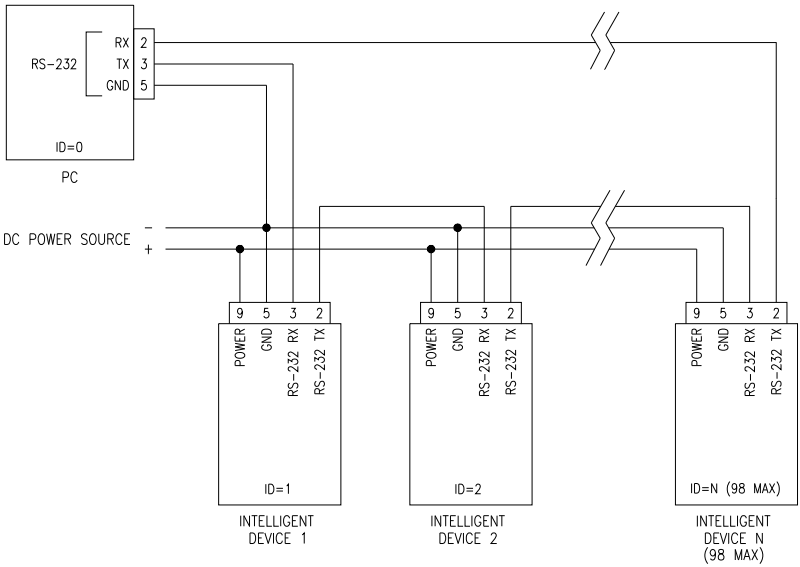


FIGURE 11-15: RS-232 Serial Loop Network

11.2.3 RS-485 Wiring Diagrams

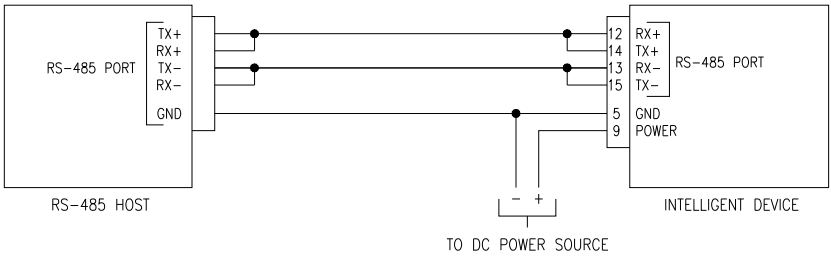


FIGURE 11-16: 2-Wire RS-485 System, Single Device

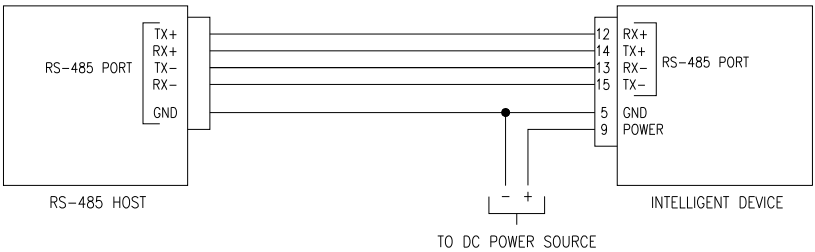


FIGURE 11-17: 4-Wire RS-485 System, Single Device

11.2.4 RS-485 Multi-Drop Network Wiring Diagrams

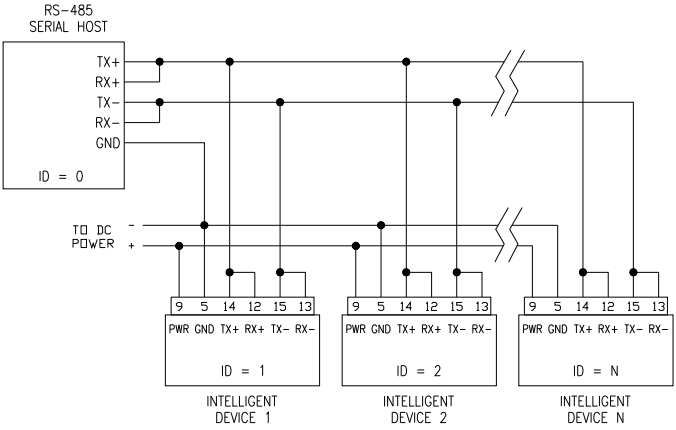


FIGURE 11-18: 2-Wire RS-485 Multi-Drop Network

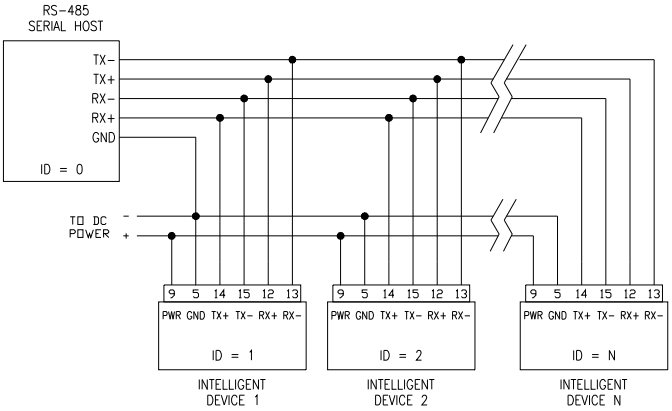


FIGURE 11-19: 4-Wire RS-485 Multi-Drop Network

11.2.5 Model 715 Display Wiring Diagrams

The following diagrams illustrate a few typical Model 715 systems. There are two ways to power the Model 715: using an optional wall power supply or via screw terminal blocks. Both methods are shown on each diagram, but only one power option is needed, and either can be selected depending on your application.

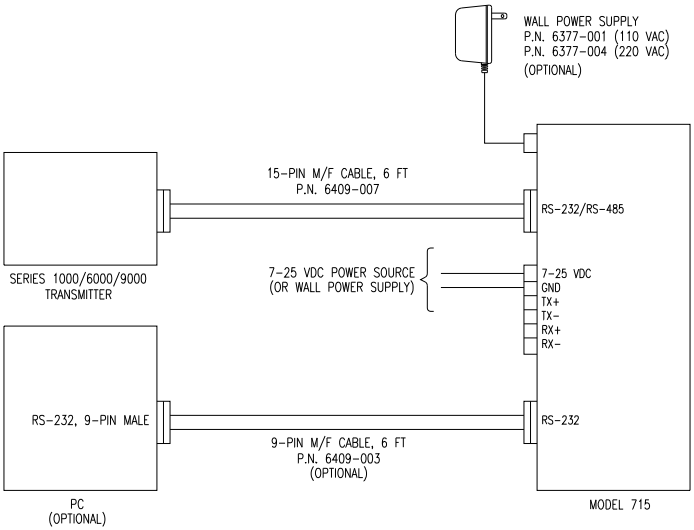


FIGURE 11-20: Simple Model 715 / Intelligent Transmitter System w/ Optional PC Shown

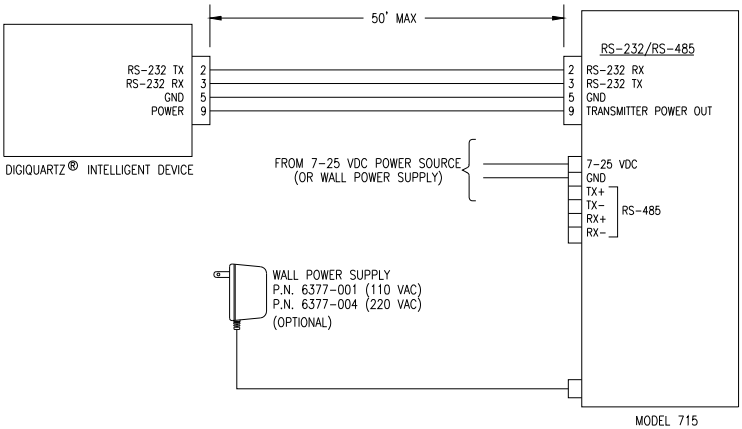


FIGURE 11-21: Model 715, RS-232 Connection to an Intelligent Device

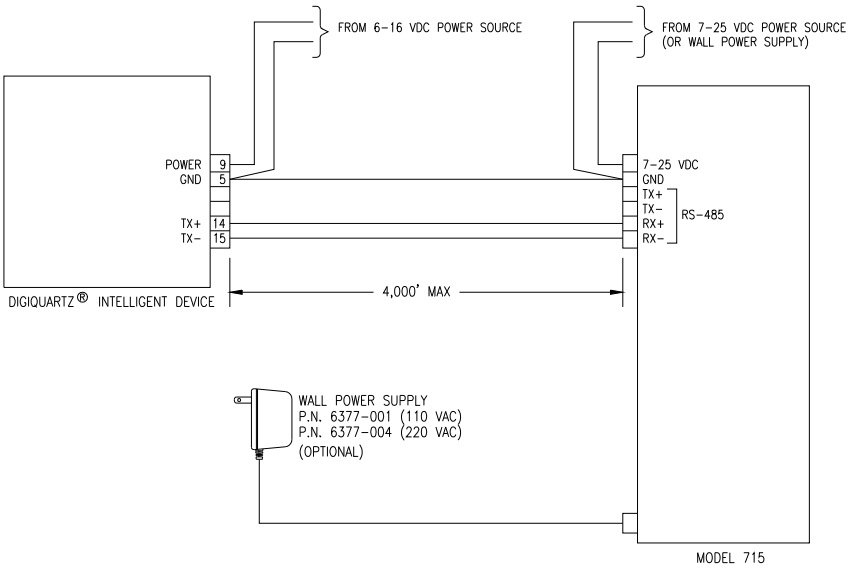


FIGURE 11-22: Model 715, RS-485 Connection to an Intelligent Device

12 Troubleshooting

12.1 Troubleshooting

The following are solutions to frequently encountered problems. If you are experiencing difficulty with a Digiquartz Intelligent device, it is likely that the solution can be found below.

NO RESPONSE FROM DEVICE

Check your connections:

- Check your connections to ensure that your system is hooked up properly.
- Check your power source to ensure that the proper voltage is supplied to the device.
- If you believe that your system is wired and powered properly, but you still cannot communicate with your device(s), try using a PC and Digiquartz Interactive software (DQI3) to verify operation and configuration of each device individually. To do this, you will need to connect each device one at a time to the PC RS-232 port. DQI3 will allow you to establish communications with Digiquartz Intelligent devices regardless of baud rate or ID settings. If your device(s) work properly with DQI3, but you are still unable to communicate with them in your system, the problem is almost certainly caused by your serial host hardware/software settings or your connections.
- If you are networking your devices, make sure that all are set to the same baud rate, and that any earlier-generation (RS-232 only) devices are set to **PT**=N (8 data bits, no parity, 1 stop bit). Also ensure that each device is set to a unique ID value.

Check your serial host:

- Make sure your serial host is configured for the proper baud rate, and 8 data bits, no parity, and 1 stop bit.
- Make sure your commands are terminated with a carriage return and line feed (ASCII 13 and 10). Your serial host hardware or software may need to be configured to provide proper command termination.
- Make sure that you are sending commands to the proper ID. If you are unsure which ID to use, try sending a global **SN** command (*9900SN), and check the response(s) to see which ID(s) responded.

INTELLIGENT DEVICE DOES NOT RESPOND TO A COMMAND, BUT RESPONDS TO SUBSEQUENT COMMANDS

- The Intelligent device is probably asleep when the first command is received, but is awake when the second command arrives. Therefore, the first command is ignored, and the second command is acted upon. To avoid this, either wake up the device before attempting a command, or disable sleep mode. Refer to the **SL** command for more information.

DEVICE REPORTS INCORRECT PRESSURE VALUES

- Check that the calibration coefficients are correct. Digiquartz Interactive (DQI3) software can be used for this purpose. The proper calibration coefficients are listed in the calibration data sheet that was provided with your Intelligent device. If you are unable to locate the calibration data sheet, contact Paroscientific for the calibration coefficients specific to your unit.

12.2 Frequently Asked Questions (FAQ)

How do I change the RS-232 / RS-485 baud rate?
Refer to Section 5.2 “Serial Communications Commands” beginning on page 27.

How do I configure my instrument?
Refer to Section 3 “Installation and Quick Start” beginning on page 19, and Section 4 “Operation” beginning on page 23.

How do I change the pressure unit?
Refer to Section 5.10 “Unit Commands” beginning on page 46.

How do I change the pressure sampling rate?
Refer to Section 5.4 “Measurement Integration Time Commands” beginning on page 36.

What are the RS-232 and RS-485 commands?
Refer to Section 5 “Command Instructions” beginning on page 27.

How do I tare the unit?
Refer to Section 5.12 “Tare and Overpressure Commands” beginning on page 49.

How do I change the information on the Model 715 display?
Refer to Section 9 “Using the Model 715 Display” beginning on page 79.

How do I change the Unit ID?
Refer to Section 5.2 “Serial Communications Commands” beginning on page 27.

13 Calibration

13.1 Pressure Calibration Procedure

13.1.1 Overview

Paroscientific transducers measure pressure with a force sensitive quartz crystal whose output period (or frequency) changes with applied load. For a given temperature, true applied pressure will generate a specific crystal period. Therefore, a measure of the crystal period will indicate what pressure is applied, provided the relationship between crystal period and pressure is known. This relationship is usually expressed as the C, D, T_0 equation. C, D, and T_0 are coefficients that are unique to Paroscientific transducers, and are different for each transducer. In addition, these coefficients are characterized for thermal effects. For each temperature, they are expressed as polynomial expansions with coefficients **C1**, **C2**, **C3**, **D1**, **D2**, **T1**, **T2**, **T3**, **T4**, and **T5**. Typically, it takes between 7 and 10 coefficients to fully describe the relationship, also called the "CD thermal model", between crystal output, temperature, and pressure.

Recalibration is necessary if a user decides that the agreement between true and indicated pressure is outside tolerances set for the particular application. Please see the documents entitled "Recalibration of Paroscientific Transducers - Doc 8140-001" and "Calibration of Digiquartz Sensors" at www.paroscientific.com for recalibration procedures and calibration software support.

Because the recalibration period of Digiquartz Instruments depends on specific applications and user requirements, we do not recommend a typical interval between calibrations. Some customers never recalibrate their instruments, while others do periodically every 1 to 3 years.

13.1.2 Zero and span adjustments

The Paroscientific pressure transducer measures a force that is generated by external pressure. Since the quartz crystal is extremely sensitive, any other small force that is transmitted to the sensing element will be added to the pressure measurement. A pressure offset generated in this way is purely additive and is the same at all pressure values. In principle, checking accuracy at a single applied pressure is sufficient to determine an offset. Of course, the offset can be calculated as the average offset of many pressure points.

Span is defined here as the pressure difference from minimum pressure to full-scale pressure. A span error is the difference between the indicated pressure span as measured by the transducer and the true pressure span. If a transducer is carefully adjusted at minimum pressure, the span error is simply the difference between indicated and true applied pressure at full scale.

The span of a Paroscientific transducer is rarely adjusted since the scale factor of the sensing element is very stable. Differences are sometimes due to different calibration standards. The span of a dead weight tester used as a primary standard depends directly on the piston area and the value of local gravity. Any apparent change of span in a Paroscientific transducer should be carefully checked to ascertain that the pressure is correctly applied and calculated with the correct piston area and gravity constant, and that the piston is vertical. We recommend recording several pressure points over the entire pressure range to establish any span error. The Paroscientific calibration software program RECAL calculates the best span by a least-squares fit optimization.

Please refer to the document entitled "Recalibration of Paroscientific Transducers - Doc 8140-001" at www.paroscientific.com for details regarding offset and span adjustment.

Calibration should only be performed by a skilled operator.

The **PA** and **PM** commands allow you to make zero and span adjustments. Normally, **PA** (pressure adder) is set to 0.0, and **PM** (pressure multiplier) is set to 1.0.

Adjusted pressure is calculated using the following equation:

$$P_{adjusted} = PM * (P + PA)$$

Where: P = Pressure calculated using original calibration coefficients, in the current pressure units
PM=the current value of PM
PA = the current value of PA

Refer to Section 5.17, page 60 for more information regarding **PA** and **PM**.

CAUTION

PA and **PM** directly affect calibration. Use extreme caution when modifying **PA** or **PM**. Improper **PA** and/or **PM** values will result in inaccurate pressure measurements.

14 Pressure Unit Conversion Table

To use this table:

- Determine original pressure unit and desired pressure unit.
- Using the table, identify the appropriate pressure conversion factor.
- Multiply the original pressure value by the conversion factor to convert it to the desired pressure unit.

TABLE 14-1: Pressure Unit Conversion Table

Original Pressure Unit	Desired Pressure Unit						
	Grams/cm^3	Pounds/in^2	Inches of mercury	Millimeters of mercury or Torr	Grams/cm^2	Millibar or Hectopascal	Pascal or Newton/m^2
	g/cm^3	psi	in Hg	mm Hg or Torr	g/cm^2	mbar or hPa	Pa or N/m^2
g/cm^3	1	1.422334	2.895903	73.5592	100.0000	98.06650	9806.650
psi	.7030696	1	2.036021	51.71493	70.30696	68.94757	6894.757
in Hg	.3453155	.4911541	1	25.40000	34.53155	33.86388	3386.388
mm Hg or Torr	.01359510	.01933678	.03937008	1	1.359510	1.333224	133.3224
g/cm^2	.01000000	.01422334	.02895903	.7355592	1	.9806650	98.06650
mbar or hPa	.01019716	.01450377	.02952999	.75000617	1.019716	1	100.0000
Pa or N/m^2	1.019716x10-4	1.450377x10-4	2.952999x10-4	7.500617x10-3	.01019716	.01000000	1

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15 Command and Parameter Index

TABLE 15-1: Action Commands

COMMAND	DESCRIPTION	PAGE
BL	Lock baud rate	28
BR	Set baud rate	27
DB	Dump buffer	34
DS	Dump buffer sequential	35
DT	Display text on second line	58
E1	Sample and send one compound period per P1/Q1 format	32
E2	Sample and send continuous compound period per E1 format	33
E3	Sample and send one compound measurement per P3/Q3 format	33
E4	Sample and send continuous compound period per E3 format	33
E5	Sample and send one compound value per P3/P1/Q1 format	33
E6	Sample and send continuous compound values per E5 format	34
EW	Enable write	27
ID	Set unit ID	28
M1	Output timestamp for minimum pressure value	44
M3	Output timestamp for maximum pressure value	44
MR	Reset minimum and maximum pressure value	45
OI	Select sequential or simultaneous pressure integration	43
OF	Execute user-defined command	42
P1	Output single pressure period value	29
P2	Output continuous pressure period values	31
P3	Output single pressure values	29
P4	Output continuous pressure values	30
P5	Sample and hold a pressure value	34
P6	Sample and hold a pressure period value	35
P7	Output continuous pressure values at maximum rate	30
Q1	Output single temperature period value	29
Q2	Output continuous temperature period values	31
Q3	Output single temperature value	29
Q4	Output continuous temperature values	32
Q5	Sample and hold a temperature value	35
Q6	Sample and hold a temperature period value	35

TABLE 15-2: Parameter Commands

COMMAND	DESCRIPTION	PAGE
C1	C1 coefficient	61
C2	C2 coefficient	61
C3	C3 coefficient	61
CF	Firmware checksum	55
D1	D1 coefficient	61
D2	D2 coefficient	61
DL	Fixed-field data format	54

TABLE 15-2: Parameter Commands

COMMAND	DESCRIPTION	PAGE
DM	Second line display mode	56
DO	Display data output port	57
DP	Decimal places in displayed pressure value	57
FM	Fetch mode enable/disable	44
IA	IIR mode cutoff frequency	64
MD	Serial data model	45
MN	Model number	55
OI	Sequential / simultaneous integration mode	43
OM	User-defined command definition	42
OP	Overpressure alarm setpoint	51
PA	Pressure adder	61
PF	Full-scale pressure	55
PI	Pressure integration time (time-based)	36
PL	Overpressure indication setpoint	58
PM	Pressure multiplier	61
PO	Pressure transducer type	56
PR	Pressure integration time (period-based)	37
PS	P7 temperature measurement interval	31
SL	Sleep mode enable / disable	48
SN	Serial number	55
ST	Sleep timeout	49
SU	Data separation character enable/disable	53
T1	T1 coefficient	61
T2	T2 coefficient	61
T3	T3 coefficient	61
T4	T4 coefficient	61
T5	T5 coefficient	61
TC	Timebase correction factor	62
TH	Pressure measurement data rate	39
TI	Temperature integration time (time-based)	37
TR	Temperature integration time (period-based)	37
TS	Time reference stamp enable/disable	59
TU	Sensor temperature unit (^{o}C/^{o}F)	48
U0	U0 coefficient	61
UF	User-defined unit factor	47
UL	Stored text to display on line 2	58
UM	User-defined pressure unit label	54
UN	Pressure unit	46
US	Serial data unit suffix enable/disable	52
VR	Firmware version	55
XM	Resolution mode	64
XN	Number of significant digits	67
Y1	Y1 coefficient	61
Y2	Y2 coefficient	61
Y3	Y3 coefficient	61
ZE	Set or read tare mode	49
ZI	Tare serial indication enable/disable	53

TABLE 15-2: Parameter Commands

COMMAND	DESCRIPTION	PAGE
ZL	Tare lock	51
ZS	Tare switch state	50
ZV	Tare offset value	50

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